CONDITIONED REFLEXES AND PSYCHIATRY

Lectures on Conditioned Reflexes

VOLUME TWO

CONDITIONED REFLEXES AND PSYCHIATRY

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To one of my earliest medical friends

MAURICE CHARLES PINCOFFS

from the Translator

TRANSLATOR'S PREFACE

SINCE the publication of *Lectures on Conditioned Reflexes* (International Publishers, 1928), Pavlov has added a new chapter to his investigations. It is not the fortune of many to explore a fresh field of inquiry after the age of seventy-five. In this volume, comprising Pavlov's writings from 1928 to his death in 1936, Pavlov made a scientific advance into the domain of psychiatry, extending and adapting the concepts derived from the purely physiological and animal researches to the psychiatric patient.

These lectures are concerned with the physiological analysis of human conditions shading from the normal to the definitely pathological, from the analysis of types, as artists and scientists, to a discussion of the mechanisms of hysteria, obsessions, functional paralyses to those of catatonia and that most common form of insanity, schizophrenia.

During the last decade of his life Pavlov applied himself with his usual daring and foresight to clinical problems. Of the conditions of which he writes, he speaks from first-hand knowledge, even though derived in the closing years of his life. And he actually kept up his scientific studies (through self-observation) until the last few minutes of his life!

The present volume contains Pavlov's official lectures and some unpublished papers from the time of the publication of the first volume (*Lectures on Conditioned Reflexes*) until his death in 1936. The chapters are numbered continuously with Volume I. Together the two volumes contain all of Pavlov's public lectures on conditioned reflexes from the time of the winning of the Nobel Prize in 1903 to 1936; they are the only complete collection of Pavlov's lectures on conditioned reflexes and psychiatry in any language.

The biographical sketch deals with the closing events of his life as well as a critical evaluation of him and his work. That part of his life prior to 1928 is given in the biography included in Volume I of *Lectures on Conditioned Reflexes*. The material comes from my five years in Pavlov's laboratory, visits to him in 1933 and 1935, and material received from his pupils (especially Orbeli, Volborth, Kupalov, Anochin, Speransky, Andreyev). Among those on this side of the Atlantic who have helped either with the material or the MS. are W. B. Cannon, B. P. Babkin, John Fulton, Maurice Hindus, John Dos Passos, Houston Peterson, Alan Chesney.

W. Horsley Gantt

Wingina, Virginia
October, 1940

INTRODUCTION

By W. Horsley Gantt

I. PERIODS OF WORK

"I must hurry because I am getting old; I have much work to finish before I die; I want to work until I am 90 and then I'll stop experimenting and write." This statement of Pavlov (made to me in 1933) reminds one of the motto of another great countryman who wrote on his seal, "I am of those who seek knowledge and are willing to learn" (Peter the Great). The fact that Pavlov wished to postpone the transfer of his activities from the laboratory to the desk till the age of 90 is evidence of his preference for the perennial search for experimental facts as opposed to the writing down of his results. Like most creative-minded persons he delayed what he would rather not do, and did what was nearest his heart. It is doubtful whether he actually expected to labour till 90; for at the International Physiological Congress in Rome in 1932 he said: "Now I suppose that for the last time I stand before a general meeting of my colleagues," and even in 1929 when he said good-bye to me at Chelmsford, Greenwich, he added, "I suppose it is farewell for always!"

That he would have written either of the books on conditioned reflexes unless he had been persuaded by his pupils to do so is unlikely. The stimulus for one of these two books was the threat from a pupil that he himself would attempt to write a book on the conditioned reflexes unless Pavlov did, and Pavlov yielded rather than permit some one less capable to describe those experiments from which even Pavlov shrank from making general conclusions.

When in 1929, after my five years as a collaborator, I sadly parted with Pavlov thinking it the final farewell, little did I imagine that after his eightieth year he would open a new chapter to his work. But this volume, consisting of lectures given since 1929, is evidence of his continued efforts and venture into the field of psychiatry.

Pavlov's scientific life and effort might be divided into four parts: (1) the early research on circulation and the heart, (2) the central period of investigation on the physiology of digestion, (3) the bulk of the work on conditioned reflexes, and (4) his venture into psychiatry by means of the conditioned reflex concepts and methodology. Besides the numerous reprints from his laboratories, four books of Pavlov's now describe the above phases of the work: *Work of the Digestive Glands*, published in English in 1898 (Chas. Griffin, London, 1910); *Conditioned*

Reflexes (Oxford Press, 1927), *Lectures on Conditioned Reflexes,* Vol. I (International Publishers, 1928), and the present volume describing his approach to clinical psychiatry.

The years between 1928 and Pavlov's death, February 27, 1936, at the age of eighty-six and a half years, were filled with activity and scientific achievement in a new field, the results of which are described in this volume.

Pavlov's courage and daring were shown by the bold attempts to apply his concepts to psychiatry after the age of 80. "He had the courage and setting for adventure and he knew it" (Adolf Meyer—personal communication). Having never been a clinician, he states that he had had no experience or knowledge of clinical psychiatry since his student days of which he had retained not a trace. Thus with a clean slate after he had passed the fourscore year mark, he began the serious study of psychiatry, which he continued till the end of his life. Several times a week he visited psychiatric wards and discussed cases with the psychiatrists. In September 1933 I found him aglow from the visit of Adolf Meyer, the dean of American psychiatry at that time; and his desk was covered with the current texts of psychiatry in English, German and French.

This entrance of Pavlov into psychiatry at 80 was the second major turning point in his scientific work. The first, when he was 50, occurred in the study of digestion on meeting with a type of gastric, pancreatic and salivary secretion which differed from the ordinary physiological secretion, *i.e.*, the *conditional* reflex secretion. The decision to enter this new field entirely unfamiliar to him was a momentous event made after a great struggle and upheaval in the whole laboratory.

Pavlov's second great adventure was not after the same pattern as the first. Although the new field (psychiatry) was as unfamiliar as was the old one (behaviour, physiology of the brain) in 1903, the step was taken without the former misgivings (which halted him for a year or more), and even with the feeling of a crusader who had a message for the world. Nevertheless, Pavlov's attack on the problems of psychiatry was a sincere attempt, partly theoretical, partly factual, to apply the results of the laboratory to the clinic.

More than a gesture was his statement in 1933, when I visited him in his new laboratory at Koltushy:

"These are our facts, I do not know what the psychiatrists will say, but," with a fierce gleam in his eye, "we shall see who is right!"

And of his own ability as a psychiatrist he showed humility combined with a furious enthusiasm for the subject:

> I am no clinician (I have been and remain a physiologist), and, of course, at present (so late in life) would have neither the time nor the possibility to become one. Owing to this, in my present conclusions as well as in my former excursions

into neuropathology and psychiatry, while discussing corresponding material, I dare not aspire to sufficient competency from a clinical point of view. But I certainly shall not be erring now if I say that clinicians, neurologists and psychiatrists, in their respective domains, will inevitably have to reckon with the following fundamental patho-physiological fact: the complete isolation of functionally pathological (at the actiological moment) points of the cortex, the pathological inertness of the excitatory process, and the ultraparadoxical phase.

II. APPLICATION TO PSYCHIATRY

Pavlov's applications of his concepts to psychiatry in the last decade of his life were based upon his previous experimentations with dogs. An analogy was made between the symptoms obtained in the laboratory with those seen in patients. By this method he thought that he was able to illuminate the origin and development of the several forms of human psychoses, particularly schizophrenia, hysteria, obsessions and paranoia.

The observations upon which his deductions were based concerned, first, his four constitutional types or temperaments—those in which excitation predominated (choleric, sanguine) and those in which inhibition predominated (phlegmatic, melancholic). The central group which did not ordinarily break down included the sanguine and the phlegmatic—both, however, stable, well-balanced animals. The extreme groups, choleric and melancholic were liable to a breakdown either in the direction of excessive excitation or excessive inhibition.

As causes of the experimental neurosis Pavlov considered not only the type of animal (heredity), but the situation (environment), the chief elements of which had to do with the method of giving the conditioned stimuli involving a "collision between the excitatory and inhibitory processes." In Vol. I of *Lectures on Conditioned Reflexes* Pavlov described the experimental neurosis, or disturbance of behaviour in the animals; entailing a so-called collision of the excitatory and inhibitory processes. In the present volume he showed that, in addition to collision, an excessively strong excitatory stimulus would also produce a disturbance. The intensity of the conditioned reflex has been shown (by Gantt *et al*), to depend upon the intensity of the unconditioned stimulus, *i.e.*, the motivation or emotional tension, and by Pavlov (Lyman, Kupalov, *et al*), to depend also upon the intensity of the conditioned stimulus—a loud bell produces a greater food excitation than a faint one. This is true within certain ranges of the intensity of the conditioned stimulus, but beyond a certain maximal intensity variations of the effect may lead to certain phases—equivalent (in which strong and weak stimuli produce the same effect), the paradoxical (in which the weak stimuli give a greater response than the strong), the ultraparadoxical (in which the excitatory conditioned stimuli become inhibitory and vice versa). Such

conditioned stimuli, too strong to give the maximal conditioned reflex, Pavlov termed transmarginal or supramaximal, which I have translated here as ultramaximal.

Pavlov considered that inhibition was a protective mechanism. When the conditioned stimuli became so strong that the result produced would exceed the capacity of the given nervous system, by the foregoing law excitation became replaced by inhibition, thus protecting the weak cortical cells from excessive excitation. Underlying this explanation was the hypothesis that excitation and inhibition rested upon independent substances. Although there is little experimental evidence for such a view, in recent years an indication of its truth has been received from the experiments of Loewi, Babkin, Wolff; Stavraky on acetylcholin as a stimulus for certain peripheral nerves and the experiments of Cannon, Rosenblueth, Rioch *et al* on sympathin—a substance stimulating peripheral nerves having in general opposite effects to those stimulated by acetylcholin.

In dogs with a "weak nervous system" the above-described phases, particularly the ultraparadoxical, were prominent. Such animals showed negativism, stereotypy and other symptoms comparable to what is seen in the schizophrenic patient. For example, these dogs continued to make certain useless, stereotyped movements over and over again. "Negativism" was expressed by their refusal of food, when it was offered, and, on the other hand, turning toward food as it was taken away. Also some of these dogs fell into a "hypnotic" state in which there was paralysis of the motor skeletal musculature, especially of those muscles most concerned with the given excitation, *i.e.*, those of eating. Such animals stood like marble statues, drooling at the mouth but unable to take the food. These Pavlov considered analogous to the patients, catatonics, who exhibit catalepsy and remain immobile to even painful stimuli, and consistently refuse food so that they have to be fed through the nose. Cyclism has also been seen in certain of Pavlov's dogs, corresponding to the succession of mania and depression in human patients.

As a result of Pavlov's observations in the psychiatric clinic, he postulated about the nature of hysteria. He noted that much of human behaviour was based upon a set of *symbols* (Adolf Meyer) or signals entirely lacking in the animal—the signals of speech. Such signals were considered as a secondary signalling system, built upon the primary signals or conditioned stimuli. On this basis Pavlov divided people roughly into two groups, artists and thinkers; the former depending chiefly upon the primary signals and the latter upon the secondary.

In chapter LII Pavlov considers hysteria as a disease affecting the secondary group of signals or language field. When these signals fail to function normally, certain "ideas" in the patient's mind become con-

nected through the nervous system to the muscles or other tissues, resulting in paralysis, anesthesias, or even an increase of adipose tissue such as is seen in hysterical pregnancy.

Obsessions and paranoia were explained by Pavlov on the basis of certain experiments, as described in chapter LV. In dogs of a "weak nervous system" or in those made weak by castration, the following results were obtained. A close differentiation was made between two metronomes of different frequencies. Then an attempt was made to connect the excitatory conditioned stimulus produced by the positive metronome into inhibition and the inhibitory produced by the negative metronome into excitation. "In one of the castrates of the strong type the procedure met with comparative success. In the other animals transfer was taking place when a peculiar state of affairs set in." In summary the effect of this pair of metronomes remained isolated and did not extend to other functions as it should normally; it showed a pernicious type of stability or inertia. However the excitation produced by other stimuli was entirely normal in function. Such an isolation of a pathological process—a "sore point"—Pavlov considered analogous to paranoid development in patients, who show normal intelligence in all spheres of life except those which have to do with the pathological point.

Although Pavlov's views on psychiatry are characterised by a remarkable clarity and handling of the chief symptoms, as well as by brilliant analyses from the strictly experimental Pavlovian point of view, several fundamental questions arise. First the reliability of the analogies. It is one thing to see a certain objective symptom in a dog or a patient but quite another to compare the objective manifestation in the dog with a psychiatric "disease entity" (if such there be). Our information of the latter and its diagnosis and naming rests more upon what we obtain and know about the subjective life of the patient than upon the objective manifestations, and as long as these are the chief bases for the classification of patients it seems unwise to attempt an identification with a disease. The dividing line between schizophrenia, manic-depressive psychoses and psychoneuroses has often been too shifting to warrant a tie-up between the experimental condition and a strict disease entity. As long as the analogy is only between symptoms and origins we are on surer ground.

Pavlov's analogy with paranoia is certainly of provocative interest. But it remains to be seen whether the inertia of the pair of metronomes in the disturbed, weak dogs is really analogous to the fixed ideas of the paranoiac.

Inertia is, as Adolf Meyer points out, too passive a term for the rigidity of the paranoiac: "plasticity is limited and warped . . . the pathology of paranoia is not mechanics, but dynamics of life got out of

line, out of the furrow." Inertia, in the physical sense of continuation of motion once started, is nearer the truth. Furthermore the classification of dogs who show one or another nervous disturbance as having a weak nervous system is confusing, as the evidence for a weak nervous system is drawn entirely from laboratory data and based on the assumption that we really know what we mean by a "weak nervous system" or a "strong nervous system." Regarding an attempt at rigid classification Cannon relates the instance of a collector who thought he had made a complete description of a certain group of corals. When he was about to publish his treatise he received from Australia a lot of corals which did not fit into the specific types he had distinguished. Throwing the new forms on the concrete floor he ground his heel into them, exclaiming "Damn the intermediate species!"

"Pavlov was guilty of over-simplifying an extraordinarily complex subject, but as a first approximation in a field where doubt, mystery and prejudice reigned before, it had the outstanding virtues of a new and compelling hypothesis: it crystallised a great problem and clearly indicated the path to be followed for its solution."[1]

III. SCIENTIFIC PRINCIPLES

In his letter to the young scientists, his "last will and testament," written a few months before his death, Pavlov formulated certain rules of work for the investigator. This letter is given in full in the appendix.[2]

1. *Planning.* "Scientific discipline and systematic planning in the amassing of knowledge."

"Pavlov believed that scientific success may be achieved only when the work is done systematically. He did not like the type of worker who jumped from one subject to another, or who hunted after a spectacular discovery. He considered that only systematic work, progressing step by step in a definite field, would be fruitful." (Boris P. Babkin, in a letter to the translator, June, 1940.)

2. *Thoroughness.* "Learn the A B C's of science before attempting to ascend its heights. Never reach for the next step before having mastered the preceding one."

It was in this spirit of learning the A B C's of science that Pavlov at 70 began to visit the psychiatric wards every Sunday, and a decade later launched out on the serious study of psychoses from the laboratory point of view.

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[1] John Fulton, "Ivan Petrovitch Pavlov," *Scientific Monthly,* April, 1936, Vol. XLII, pp. 374-377.

[2] See also L. A. Andreyev, "The Great Teacher and Master of Science," *Scientific Monthly,* August, 1937, pp. 159-171.

3. *Observation.* "A physiological experiment may depend upon a mass of petty conditions and unexpected occurrences which should be observed during the experiment, otherwise our material loses its real purport."

Over the laboratory at Koltushy, Pavlov had inscribed "Observation and observation." How often the keen power of observation had furnished Pavlov with facts, guided him to the next stage in his experiments.

"The very best themes, the most profound questions were conceived during an experiment, while working."

"One of the dogs operated on by our method began, some ten to fifteen days after the operations, to be affected by the corrosive action of the juice. Our methods did not completely attain the end sought. The dog was kept chained in the laboratory. It so happened that one morning, to our sorrow, a heap of plaster broken from the wall was found near the dog, which usually was very quiet. The dog, still chained, was moved to another part of the room. The following morning the same story had been repeated! Again the wall had been ruined. At the same time it was noticed that the dog's abdomen was dry and that the inflammation of the skin had diminished. Only then we finally guessed what was the scratching at the wall and why slumber no longer harmed him. We (Dr. Kuvshinsky and I) gratefully recognised that by its intelligence the animal helped not only itself but also us."

4. *Facts.* "Esteeming the language of facts the most eloquent" as Pavlov stated in his lecture in Madrid in 1903, is an indication of his respect for facts.

"Study, compare, and accumulate facts. No matter how perfect a bird's wing, it could never raise the bird aloft if it were not supported by air. Facts are the air of the scientist. Without them you will never be able to soar. Without them your 'theories' are useless efforts."

"However, the mere accumulation of facts without a general idea in mind, without a plan, is a useless occupation. . . . Try not to stop only at the surface of a fact. Don't become an archive of facts. Try to penetrate the secret of their appearance. Obstinately seek the laws governing them. The aim toward which facts are accumulated is precisely this last point—the discovery of the laws governing facts. Thus a fact is not an end in itself, but only the means toward mastery of the general laws of nature." (Andreyev.)

5. *Ideas.* "When you have no ideas you can't see the facts." In the accumulation of facts Pavlov allowed his scientific imagination free play. He would formulate an idea on which to arrange his facts. Frequently he would sit quietly in an armchair, with hands folded, talking out loud

to himself. When this occurred in the laboratory there was great excitement. Pavlov would listen patiently to the ideas of his collaborators, encouraging some, but vehemently criticising pure speculative philosophy—verbal associations not dependent upon facts.

Pavlov was in full agreement with Claude Bernard who wrote seventy-five years before:

> Une idée anticipée ou une hypothèse est donc le point de départ nécessaire de tout raisonnement expérimental. Sans cela on ne saurait faire aucune investigation ni s'instruire; on ne pourrait qu'entasser des observations stériles. Si l'on *expérimentait* sans idée préconçue, on irait à l'aventure; mais d'un autre côté, ainsi que nous l'avons dit ailleurs, si l'on *observait* avec des idées préconçues, on ferait de mauvaises observations et l'on serait exposé à prendre les conceptions de son esprit pour la réalité.[3]

Of the function of theory in science, a great contemporary scientist (E. H. Haeckel, in *Riddle of the Universe*) says:

"All sound science aims to attain a knowledge of the truth. This knowledge ultimately consists of impressions made on our sense organs by the outer world, and is limited by the nature of those organs. . . . However, the thinker is not content with the defective knowledge of the outer world which is obtained through our imperfect sense organs. He builds up the sense impressions into ideas, and he fills up the gaps of this knowledge with what may be called, in the broad sense, faith. Science cannot advance without the use of this faith, in the form of theories and hypotheses. . . . The only true revelation is found in the candid and patient study of nature."

6. *Humility.* "To err is nothing to be ashamed of. How many times have I been greatly mistaken! If you think, you make mistakes. He who never thinks never errs."

"Don't allow yourself to be overcome by pride. On account of pride you will be stubborn where it is necessary to be conciliatory; you will reject useful advice and friendly assistance; you will lose your sense of objectivity." Pavlov quoted Newton who said in his closing years "It has always seemed to me that I resemble a little boy playing with shells at the seashore, while the entire ocean of knowledge rolls before me untouched." Pavlov taught his students to avoid stereotyped ideas and a tendency to work with preconceived notions. He himself was always ready to discard any theory or idea, no matter how attached he had become to it, once it did not fit the facts.

7. *Methodology.* "Science moves by jerks, in dependence upon the successes made by the methods used. It is as though to every advance of the method we move one step higher and from this higher step are disclosed to us wider horizons including objects previously unseen."

[3] *Introduction à l'étude de la Médecine Expérimentale,* Paris, 1865, p. 57.

Pavlov's ingenuity in discovering methods was what enabled him to study so successfully the secretions of the stomach, pancreas and liver, and finally to use the salivary gland as a quantitative measure of cortical excitation.

8. *The study of the whole animal.* Pavlov was the first physiologist to study the digestive secretions in a normal animal over a long period. "Only when we keep in mind the whole—the normal operation of one or another branch of an organism—can we differentiate without difficulty the accidental from the essential, the artificial from the natural; only then we can easily find new facts and often notice mistakes quickly." . . . "The complex can only be conquered by science by one part at a time and in sudden attacks, but gradually becomes more and more embraced by it."

9. *Passion.* When Pavlov added to this a final quality "passion," the will to give one's life for science—he gave in one word the best characterisation of himself ("science requires your whole life, and even if you had two lives to give it would still not be enough"). During his whole professional career the thing that marked Pavlov from the ordinary investigator was this strong passionate yearning, this consuming zeal that drove him along in an intense, unremitting search for scientific truths. Andreyev describes Pavlov's thinking out theories thus:

> Pavlov's thinking was based on concrete facts—he kept firm hold of the experimental basis. In this regard he was brilliantly able to discipline both his thinking processes and his speech. There was no cleavage between reality and his ideas. But in the process of work, when a scientific theory or a working hypothesis was formulated, Pavlov allowed himself, as he expressed it "to give free rein to fantasy." He seated himself comfortably in a convenient armchair, adopting a pose which was somewhat unusual to him, when the usual tensity of his muscles and his customary mobility vanished. His expressive and restless hands were folded together and stilled. His words flowed smoothly and calmly. Ivan Petrovitch was thinking out loud. A strange feeling pervaded his listeners. It seemed as if the entire creative process was taking place before their eyes, as though under a bell-glass. In these minutes his mind rose to mighty generalisations. For many days after this the laboratory remained in a state of great excitement. The idea thus born was given over for "working out." There arose a harmonious structure of mental conclusions, logically deducted from the critical examination of facts.
>
> Collaborators also were allowed to give free flight to their fancy. Pavlov usually listened to these visionaries with a humorous smile of good will. Inventiveness was encouraged; but groundless, unsubstantiated fantasy was categorically condemned.[4]

IV. CRITICAL EVALUATION OF PAVLOV'S WORK

Pavlov undoubtedly stands in the front rank of scientists. The praise and admiration which he received during his life-time were often enthusiastic, eulogistic and even ecstatic to a point seldom ascribed to an

[4] L. A. Andreyev: "The Great Teacher and Master of Science," *Scientific Monthly,* Vol. 45, 1937, pp. 166, 167.

investigator but more usually partaking of that received by a national hero.

Occasionally there were exceptions. He had his professional enemies. (He said, "Protect me from my friends, I will protect myself from my enemies"). Bechterev, for example, contending that he and not Pavlov was the discoverer of the conditioned or association reflex, never ascribed credit to Pavlov but criticised his concepts and explanations until the end of his life, often in a subtle, indirect way. Pavlov, on the other hand, sharply and boldly attacked Bechterev on the basis of accuracy in some of his reports. This was a case of scientific rivalry often seen among investigators. Pavlov's attacks upon Bechterev were direct, brief, and sharp.

Pavlov made a deep impression not only upon his pupils but upon all those who met him. Whoever visited his laboratory usually came away with exultant reports: Wells, for example, "Pavlov is a star who lights the world"; Yerkes, "The years fell away as he talked"; Cannon, "For indefinite time Pavlov will remain a shining example of Russian genius"; Paul de Kruif, "The Liberator of Mankind . . . the Pasteur of the human brain and heart . . . more than a man without greed—as most searchers are. It took me 13 years to see he was the first scientific man *against* greed. . . . Russian Saint of Science. . . . So I just sat there being impressed that I was sitting in the same room with Pavlov"; Wm. B. Smith, "The greatness of his personality will surely survive, adding fadeless honour to science as well as to the Russian name"; Harvey Cushing, "Not only acclaimed the most notable figure of the great assemblage (XIII International Physiological Congress, Boston, 1929), but he proved to be the most eager and untiring participant";[5] L. F. Barker, "The greatest reputation of all physiologists of his time."[6]

The explanation of Pavlov's remarkable influence upon both his pupils and all those who met him is not difficult. He was not a politician, a tempter, or a man of artificial histrionic tendencies. His qualities were those which excite in all humanity that emotion leading to applause and the exclamation "Here was a man!" First among these was his absolute sincerity and courage. Fear was unknown to him. In declaring his convictions he said what would have been considered for others provocative and dangerous, moreover preferring to make such statements in the face of the enemy rather than in the rear. This was true whether his audience was a distinguished visitor or not. Often vehement and denunciatory as a political speaker, he was not, however, needlessly rude nor insulting.

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[5] *Soviet Russia Today,* April, 1936, p. 9.

[6] *Ibid.,* p. 29.

Next to these qualities was his unbounded enthusiasm for the object demanding his attention, whether this were an athletic sport, a dog which was the subject of important experiments, or a well thought out theory. There was in his nature a certain ruggedness as well as a boyish naïveté. Eckstein recalls the following: "I knew Pavlov a little, visited him in the last months of his life, and my feeling about that visit could be summarised in the final five minutes. He sat me down on a couch. He wanted to show me a neurotic dog, but first wanted me to understand the physiological theory by which the neurosis had been produced. For this he needed his one hand to drive home his points, while his other held my wrist and repeatedly squeezed it with such an energy that the pain prevented my hearing what he was saying. It was that kind of intensity he had. He was eighty-six." [7]

Aside from these personal rivalries, criticism has come from those who resented his tendency to extend the conditioned reflex ruthlessly over vast fields of complex data, for instance when he casually "solved" some of the most abstruse problems of social science and philosophy in the magic phrases, "reflex of freedom," "reflex of purpose" (see chapter headings in *Lectures on Conditioned Reflexes,* Vol. I).

Discounting these extreme criticisms Pavlov was vulnerable for several reasons. He was no true philosopher in the sense of one capable of surveying the whole field of knowledge and its correlations. The general truths that he expressed were narrow and limited because they were based nearly exclusively upon his own limited experimental data. He was an intensive investigator rather than an extensive thinker. He knew little of practical life; he was not a practical "psychologist," he did not concern himself with motives and emotions. He was so impractical in the routine of life that he could not be trusted to buy his own clothes, or a railroad ticket—he said he was no more than baggage when he travelled, but he recognised these failings and avoided being a fool by "rendering to Caesar what is Caesar's."

Though always honest, Pavlov was not always just. He often gave marked preferences to one pupil over another, frequently because this particular person had obtained interesting results in a problem in which Pavlov was especially engrossed. That type of injustice was not however a conscious injustice. Often Pavlov would manifest a bad feeling toward some one for a good reason and recognise it as a prejudice. In 1927 he said to me that his relations with a certain well-known American physiologist had been "spoiled" because of an unfavourable opinion this physiologist gave to a publisher on one of Pavlov's books considered for translation, that this was a prejudice which he was sorry to say could

[7] Personal communication.

not be easily overcome—although Pavlov was much more concerned over the opinion of the physiologist than the prospective translation (which Pavlov himself obstructed). Pavlov's volatility often led him to make vehement remarks to his co-workers or others which he afterward apologised for or forgot.

Though often kind and benevolent, Pavlov's nature was predominantly a fighting one. Vehement and irascible, his spleen was generally soon vented. Occasionally, however, he committed deeds which were very inconsiderate or even ruthless. One instance was reported to me when he successfully prevented a former collaborator from getting an appointment because of an old quarrel. With another of his later pupils he parted company (about 1920) in great rage (justified however by the alteration of figures in a protocol), having nothing to do with him for several years, but finally burying the hatchet when this collaborator became a successful investigator abroad.

The evaluations of Pavlov and his work vary from the statement Bernard Shaw made to me (in personal conversation at Lady Astor's, July, 1935), "Pavlov is the biggest fool I know; any policeman could tell you that much about a dog," to that of Wells, that Pavlov's fame will grow with the ages and his voice become louder with time, and exist long after the echoes of Shaw's bombastic utterances have been forgotten. Between this frank hostility of his opponents and the unreasoning eulogies of his admirers there is still much concerning his work to be written and evaluated.

Pavlov's ingenuity and skill as an experimenter is, I believe, unquestionably of the highest order. He had an uncanny sense for adapting the experiment to the problem, for careful controls, and for eliminating all but the one or two variables with which he wanted to work. An example is the devising of the miniature stomach in which the vagus nerve branches are intact, and the discovery of the secretory nerves to the pancreas where Haidenhain and others had failed. Here Pavlov succeeded through the use of the pancreatic fistula in the normal life of the dog in the acute experiment by eliminating the effect of the inhibitory nerves through the avoidance of shock. His celerity as an operator, even at an advanced age of seventy-five and upwards, made him the equal and superior of any clinical surgeon I have seen.

I have earlier mentioned Pavlov's emphasis on the study of the normal, intact animal. The debt of physiology here has been duly recognised, as shown by the following two statements—the first from B. P. Babkin now at McGill, one of Pavlov's oldest and most honoured pupils, and the second from Liddell (the founder of the first school in this country for continuous work on behaviour by the conditioned reflex method):

It was Claude Bernard who particularly encouraged this integrative tendency. Nobody, perhaps, has contributed more to its experimental foundation and development than Pavlov, although the same tendency is to be found in the work of other outstanding physiologists; C. S. Sherrington, J. B. S. Haldane, W. B. Cannon, for example. . . .[8]

It is perhaps directly due to Pavlov's example that the physiology of the living mammalian corpse, the narcotised or decapitated animal preparation of classical physiology, is viewed with increasing suspicion as a means of discovering facts of use in the practice of medicine.[9]

Also Pavlov's honesty and methods are in general beyond criticism. He wholeheartedly admitted the existence of secretin when discovered by Bayliss though he had to modify his own theories. And this was after he had tested the results in his own laboratory—"Of course they are right; we can not aspire to the monopoly of knowledge." He was the first to admit his error in having stated that he had proven the inheritance of acquired characteristics (conditioned reflexes).

Except for a few instances, as the above, no successful criticism has been made of Pavlov's facts. Another example referred to the data on which the law of irradiation and concentration was built. Lashley,[10] Loucks,[11] and others contended that the mathematical analysis of the experiments showed that Pavlov had insufficient factual material for the laws. Hull,[12] on the other hand, confirmed Pavlov's results in human subjects, but gave a different explanation to the facts. As far as Pavlov's experimental results have been tested it would seem, then, that no significant error has been found in any of the data. An explanation can be found in Pavlov's careful, painstaking methods, his adequate controls, his habit of giving the same problem to several collaborators working in separate laboratories or institutes, with whom he checked results and supervised experiments except in the last years of his life.

Pavlov is, however, especially vulnerable to criticism in the theories, laws and deductions which he has built upon his scientifically obtained facts. One of the most complete and valuable criticisms is Erwin Straus's *Vom Sinn der Sinne* (Berlin, 1935). "It is out of a universal atomistic conception, an atomistic interpretation also of such phenomena as rapprochement, change, direction, that Pavlov's physiology came. All physiology of the central system of man is highly hypòthetical, but

[8] B. P. Babkin. "Ivan Petrovitch Pavlov, For. Med. R. S." *Proc. Royal Soc. of Edinburgh,* 1935-36, Vol. LVI, Part III, p. 264.

[9] H. S. Liddell, "Pavlov's Contribution to Psychology." *Psychol. Bull.,* Oct., 1936, Vol. 33, No. 8, p. 590.

[10] K. S. Lashley: "Basic Neural Mechanisms in Behavior." *Psychol. Rev.,* 1930, 37, 1-24. See chapter LIII of this book.

[11] R. B. Loucks: "An Appraisal of Pavlov's Systematisation of Behaviour from the Experimental Standpoint." *Jour. Comp. Psychol.,* Vol. XV, No. 1, Feb., 1933.

[12] Clark L. Hull: "The Irradiation of a Tactile Conditioned Reflex in Man." *Jour. Comp. Psychol.,* Vol. 17, No. 1, Feb., 1934.

Pavlov's doctrine exceeds nearly all others in the number of untried or untested hypotheses" (p. 33). Sherrington, the great English physiologist of the central nervous system, remarked to a fellow physiologist after hearing Pavlov at the XIV International Physiological Congress in 1932: "His observations are the most brilliant but his deductions leave me cold."[13]

Pavlov denies that he is a mechanist in the sense in which the term has been applied to him.

> Many people, among them those who have a scientific form of thought, become indignant at these attempts at physiological explanations of psychic phenomena, calling them mechanical interpretations in a derogatory sense; I wish here to emphasise the incoherence, the absurdity of a reconciliation between the subjective and the mechanical state. For me there is here a gross misunderstanding.
>
> Certainly, one cannot think, at the present time, of representing our psychic phenomena in a mechanical way, in the strict meaning of the word, just as one would not be able to do so for physiological or chemical phenomena (those latter however are tolerated longer); it has not even happened wholly for any natural phenomena. (Chap. LIV of this book.)

In spite of these denials, it must be admitted Pavlov drew largely on the philosophy of Descartes who compared the animal organism to a machine. Pavlov's philosophy, like his experiments, was clear-cut and simple and indeed so hamstrung by his laboratory facts that he could hardly be considered a philosopher.

Not his the aloof, detached and resigned point of view that would allow him to feel:

> There was the Door to which I found no Key:
> There was the Veil through which I might not see.[14]

but the assurance that,

> Only science, exact science about human nature itself, and the most sincere approach to it by the aid of the *omnipotent scientific method,* will deliver Man from his present gloom, and will purge him from his contemporary shame in the sphere of inter-human relationships.[15]

Unless one thoroughly understands his *modus operandi,* he is likely to be misled into thinking Pavlov dogmatic and narrow minded. His readiness to abandon theories when the facts no longer support them are strong evidence that he was no dogmatist, though he often had the mannerisms of a propagandist.

Several of his characteristics are probably responsible for his apparent dogmatism. One was the habit of constructing a theory upon his facts and his feeling that a theory should serve as a test, to stand

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[13] Quoted from John F. Fulton in *Bull. of Inst. of Hist. and Med.,* March, 1940, pp. 332-354.

[14] Omar Khayyam, *Rubaiyat.*

[15] *Lectures on Conditioned Reflexes,* Vol. I, p. 41.

only so long as it explains and does not conflict with the facts, but that it was justified if it explained even temporarily. As more facts accumulated he constantly adapted old theories or invented new ones. He never hesitated to take a new position on the basis of experimental facts even if on the discovery of fresh evidence he had to relinquish it. His own mind was never closed.

One who reads carefully will find scattered throughout his writings, cautions that his work is only a beginning, that extreme care is necessary before the results are applicable specifically to man.

> In applying to man the results of investigation of the functions of the heart, digestive tract and other organs in the higher animals, allied as these organs are to the human in structure, great reserve must be exercised and the validity of comparisons must be verified at every step. Obviously even greater caution must be used in attempting similarly to apply our recently acquired knowledge concerning the higher nervous activity in the dog—the more so, since the incomparably greater development of the cerebral cortex in man is preëminently that factor which has raised man to his dominant position in the animal world. It would be the height of presumption to regard these *first steps* in elucidating the physiology of the cortex as solving the intricate problems of the higher psychic activities in man, when in fact at the present stage of our work no detailed application of its results to man is yet permissible.

Numerous examples of Pavlov's adaptations appear throughout these lectures, *e.g.*, the change in his view of external inhibition; finally considering it the same in nature as internal inhibition; also the change in his view of what clinical forms were represented by his animal neuroses.

Concerning the two "processes" (excitation and inhibition), of which he spoke most positively, he warns:

> Regarding the nervous mechanism of disturbances in inhibition we cannot hope at present to approach anything like a fundamental concept, since as yet we know little about the real nature either of the excitatory process or of the inhibitory process.

Pavlov's concepts and theories were mobile, constantly being modified with the progress of his researches.

The second reason why Pavlov has been considered dogmatic is the style in which he wrote and talked. This was both aggressive on the one hand, and on the other, boyishly enthusiastic. In him there was always, to the end, the spirit of the hunter and fighter, and after each victory the quarry was held up as a trophy for celebration.

Parenthetically, it may be said, that one of Pavlov's reiterated hypotheses, that cortical excitation and inhibition may depend upon excitatory and inhibitory substances, seems now somewhat more likely since the discovery of two substances oppositely acting on the peripheral nerves—acetylcholin and sympathin.

Some of the behaviourists have carried the exclusion of the subjective and emphasis on the objective further—even to the denial of the importance of the subjective.

A main criticism of Pavlov is—not that he failed to recognise the importance of the subjective:

> Only one thing in life is of actual interest to us—our psychical experience. Its mechanism, however, has been, and remains, wrapped in deep mystery. All human resources—art, religion, literature, philosophy, historical science—all these unite to cast a beam of light into this mysterious darkness. (*Lectures on Conditioned Reflexes,* Vol. I. p. 80.)

but that he treated the subjective physiologically. The dilemma did not go unrecognised, though it was often obscured by his zeal for the physiological hunt:

> But it is one thing to live according to subjective states and quite another thing to analyse purely scientifically their mechanism.

Here Pavlov was perhaps only reiterating in his scientific terms what Goethe said more simply: "Feeling is all, name is but smoke and sound."

Paul de Kruif asserts that "this grey-bearded old Light of the North has discovered the way to change not human nature but to alter the human heart through the human brain." It is true Pavlov's experiments did approach but did not solve the important subject of emotions. Although there was some experimenting on the effect of emotional changes, such as those produced by painful stimuli (defence), by altering the relations of the cortex to the subcortex (the sexual tensions by castration, food excitation by hunger, etc.) the general tendency of Pavlov's experimentation was to rule out and eliminate emotional changes. The application of his methods to the all-important question of emotions is one which has still to be made.

Consciousness he admitted. He first describes it factually:

> From this point of view, *consciousness* appears as a nervous activity of a certain part of the cerebral hemispheres, possessing at the given moment under the present conditions a certain optimal (probably moderate) excitability. At the same time all the remaining parts of the hemispheres are in a state of more or less diminished excitability. In the region of the brain where there is optimal excitability, new conditioned reflexes are easily formed, and differentiation is successfully developed. (*Ibid.*, p. 221.)

Then he characteristically relapses into his eidetic type of imagination:

> If we could look through the skull into the brain of a consciously thinking person, and if the place of optimal excitability were luminous, then we should see playing over the cerebral surface, a bright spot with fantastic, waving borders constantly fluctuating in size and form, surrounded by a darkness more or less deep, covering the rest of the hemispheres. (*Ibid.*, p. 222.) [16]

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[16] "This remark of Pavlov's about the quality of consciousness is one of the most stimulating and mind clearing paragraphs I have ever run across. Ever since I read it in your translation years ago it recurs to my mind when I try to image the nature of thought." (Letter from John Dos Passos.)

A fundamental question to be asked is: to what do the scientific concepts lead? William B. Smith has the following to say (unpublished MSS.):

Such, then, the situation: At the best we have a huge mass of accurately observed and even measured facts, which may be classified, in some manner systematised,[17] and described in technical terms more or less free from subjective or psychic suggestion. And we may reasonably hope for some betterment in the plight: for a steady growth in the group of facts, for increasing aptness and precision in the terms of description, for wider and exacter classification, for more studious exclusion of terms tinged with subjective reference. What more can be hoped, what more desired?

Pavlov, like Claude Bernard and many other physiologists, seeing the progress of science from a qualitative descriptive, through a quantitative and finally a mathematical stage where relations are expressed by symbols in a formula, looked for the philosopher's stone in a chemico-physico-mathematical explanation of life:

The time will come, be it ever so distant, when mathematical analysis, based on natural science, will include in majestic formulae all these equilibrations and, finally, itself.

The statement immediately following smacks of a dualistic attitude (which Pavlov, himself, denied however):

When I say this, I should like to anticipate what might be misunderstood in these statements concerning my views. I do not deny psychology as a body of knowledge concerning the internal world of man. Even less am I inclined to negate anything which relates to the innermost and deepest strivings of the human spirit. Here and now I only defend and affirm the absolute and unquestionable right of natural scientific thought everywhere and until the time when and where it is able to manifest its own strength. And who knows where its possibilities will end! (*Lectures on Conditioned Reflexes,* Vol. I, p. 129.)

A great exponent of the "common sense" method in psychiatry (Adolf Meyer) considers mathematical probability more applicable to psychobiology than mathematical certainty. And the mathematicians themselves may not be so sure of the application of formulae to psychobiological phenomena:

Well, let us suppose this scientific process carried out to its Ultima Thule. Let even the limitless power of mathematics be brought to bear; let Differential Equations, with every help from wave-mechanics and quantum-theory and Riemannian hyper-spaces, state the whole process with absolute exactitude, so that the universal state of material affairs may be read off for each instant, past, present, and future..., what then? We shall have a complete and perfect *description* of the physical world, stating its *How* fully for all time; any question as to this *How* will receive the correct answer. . . . But remember! Your question must concern *How* only. No question *Why* can receive any consideration. No query about Value or Worth can be admitted, none about Feelings, Wishes, Hopes, Fears, Thoughts or Beauty, Good or Evil, Love or Hate. The Universe stands there before you as a vast Machine, exposed in every detail of construction and working, but with never a hint of Why

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[17] "Here again, as in the whole of our research, we can only collect and systematise facts" (*Lectures on Conditioned Reflexes,* Vol. I, p. 388).

or Wherefore, of Cause or Effect, of Aim or Purpose, of Origin or End. (Wm. B. Smith, Unpublished MS.)

With this statement concerning the How and Why, both scientists and philosophers have long been in agreement:

> . . . si notre sentiment pose toujours la question du *pourquoi,* notre raison nous montre que la question du *comment* est seule à notre portée; pour le moment, c'est donc la question du *comment* qui seule intéresse le savant et l'expérimentateur. Si nous ne pouvons savoir *pourquoi* l'opium et ses alcaloïdes font dormir, nous pourrons connaître le mécanisme de ce sommeil et savoir *comment* l'opium ou ses principes font dormir. . . .[18]

> Into this Universe, and *Why* not knowing
> Nor *Whence.* Like water willy-nilly flowing:
> And out of it, as Wind along the Waste,
> I know not *Whither,* willy-nilly blowing.[19]

Psychobiologists take the view that life is organization and plasticity and that its variations can never be encompassed by chemical or mathematical formulae. The absurdity of scientific analysis pushed too far and the neglect of the principle of organisation is revealed by the statement of a chemist that "the most beautiful girl in the world is only a lump of charcoal plus some buckets of H_2O and a few ashes," a sentence which describes what should be her least worthwhile asset, her value as fertiliser rather than as a dynamic social factor. "No wife would accept a hormone for a husband" (Adolf Meyer).

In contrast to the tendency of Pavlov to make laws for the statements concerning behaviour is the view of Adolf Meyer who, while not expressing the relationships in the form of laws, emphasises both *regularity* and *plasticity* in human action, the substitute of responsibility for mechanics. "We make each other responsible to a far reaching extent, and let's own up to it. . . . Pavlov sees laws in everything, while I see laws only in the insects or decorticated animals, but not in man. . . . Instead of mechanics in the human, where speech comes in, I see plasticity."

Pavlov's position regarding analogies was rather ambiguous. Ready, on the one hand, to jump from the laboratory to such clinical conditions as paranoia, affective psychoses, obsessions, on the other hand, he frequently cautioned against human applications, almost expressing the idea of Adolf Meyer, that he should have considered "man as a new animal."

Although Pavlov's teachings are the opposite of mysticism, his beliefs were perhaps romantic, theoretical, but nevertheless they had a foundation in experimental facts. This attempt to erect such general and far-reaching truths on so limited a base was perhaps the greatest fallacy of

[18] Claude Bernard, *Introduction à l'etude de la Médecine Experimentale,* Paris, 1865, p. 142.

[19] Omar Khayyam, *Rubaiyat.*

Pavlov's work. In avoiding any theory that did not have a laboratory factual basis when the laboratory data at present could be but a small fraction of reality or even of the apparently complete knowledge on the subject, Pavlov restricted his philosophy to the life enclosed within the four walls of the laboratory.

Pavlov emphasises the objectivity of his teaching and methods. The advantage of the latter is beyond question. Pavlov rendered all mental sciences a great service when he showed how significant data could be objectively recorded. But here the objectivity stops and when he decides what to do with the facts, we return definitely to the field of subjectivity whence we started when we posed the question. Apparently Pavlov did not recognise this unavoidable fallacy for he never mentions it.

Adolf Meyer comments on Pavlov's objectivity:

> Today the Pavlovian urge for the "merely" has diminished, but the question is before us whether the possibility of an objective study does not offer highly valuable conditions for further research along lines of relatively pure culture of animal and stimuli as is the case in a physiological preparation.
>
> This I believe to be above question, and it should be possible to give evidence without falling into the error of overdoing the appearance of an unique and exclusively valid conception. I consider it a kind of privileged concentration of attention upon a special procedure and that it can contribute a great deal that is worth while without having to pose as the "only" and without speaking of other facts as "merely."

Many of the criticisms of Pavlov from the philosophical point of view are not as much criticisms of Pavlov as of the scientific method in general. The present age is one of revolution and confusion; doubt, the former ally of the scientist, is now employed even against the scientific method. Modern physicists like Eddington, questioning whether determinism is as important a factor as it was once thought to be, are inclined to substitute a probability for certainty; as to another nineteenth century fundamental, the relationship of cause and effect,—"one is almost justified in questioning the appropriateness of the word *effects*, since in reality they are action, reaction, and interaction in a sort of infinitesimal reverberation."[20]

But though science may have been excessive and overzealous, flushed with its successes in the period of Darwin, Huxley, Pasteur, Faraday, Marconi, though reaction to its cocky dogmatism (criticised in the philosophy of Bergson) may even have paved the way for the advent of the dictatorial system, we have only to refer to the above names and the things within our actual sight and hearing to refute the attack upon the empiric value of the experimental method.

However, the same dilemma is constantly before the scientist: must he build a theory to include only the *proven* facts, thus remaining an ex-

[20] Alan Gregg, "Biological Effects of Science on Man," read before American Association for the Advancement of Science, 1939 (unpublished).

perimental philosopher, or is he to provide space for all that may be discovered in the future, transcending the factual results of his own and those of his fellow travellers, and perhaps by this emphasis on the unknown as well as the known lay himself open to the charge of mysticism? And who can avoid one or the other fallacy? Only a few who must live within facts can, like Adolf Meyer, provide a system that leaves space for all known and unknown facts.

On the other hand Pavlov had the advantage of being easily understood and his theories are so clearly stated that they may be put to the test. The necessity of theory in science has been mentioned in the preceding pages, but a closing remark of the great English physiologist, Sir William Bayliss, is stated here in defence of Pavlov's manner of stating theories:

> As Bacon has well pointed out, truth is more likely to come out of error, if this is clear and definite, than out of confusion, and my experience teaches me that it is better to hold a well-understood and intelligible opinion, even if it should turn out to be wrong, than to be content with a muddle-headed mixture of conflicting views, sometimes miscalled impartiality, and often no better than no opinion at all.[21]

Straus in his brilliant treatise on Pavlov says he, like Columbus, while not finding what he set out for, nevertheless made a great discovery.

Says a prominent American physiologist and historian:

> Pavlov was indeed one of five or six individuals of the last generation who caused mankind to think in new terms; like Freud he created a new horizon, but unlike Freud he remained wholly objective in his mode of collecting scientific data.[22]

Let us then accept Pavlov at his word, admit that his imposing and clear-cut theories conveyed by the terms, concentration and irradiation of excitation and of inhibition, induction, internal inhibition and sleep, are but stepping stones, or are even beyond the pale, that they have served their day, what then remains? Granted that these should one day reach the scrap-heap, are we left emptyhanded? For generations to come every investigator in the field of physiology and more especially psychobiology may be thankful to Pavlov for having blazed a path, for having demonstrated the use of an objective method to measure important aspects of behaviour (as well as of secretion) in the intact, healthy, though restrained, animal. Pavlov's careful elaboration of the method and the painstaking, scientific, and bold demonstration of its use will permanently elevate him to a place among the Great Scientists.

> Up from Earth's Centre through the Seventh Gate
> I rose, and on the Throne of Saturn sate;
> And many a Knot unravel'd by the Road,
> But not the Master-knot of Human Fate.[23]

[21] Sir Wm. M. Bayliss, *Principles of General Physiology,* 1931, p. xviii.

[22] John F. Fulton, "Ivan Petrovitch Pavlov." *New England Jour. of Med.,* March 5, 1936, Vol. 214, No. 10, p. 5.

[23] Omar Khayyam, *Rubaiyat.*

V. CLOSING YEARS

Few men have had their later years as well rewarded and so full of satisfaction as had Pavlov's. If he had died a decade or two earlier that would not have been true, for changes subsequent to the Great War and the Revolution, with their inevitable social adjustments, brought a period of anguish to the veteran scientist. In Volume I of *Lectures on Conditioned Reflexes,* I have mentioned that Pavlov was at first out of sympathy with the Soviet Government, and did not fail to shout his defiance from the housetops.

Pavlov kept up his attitude of bold animosity toward the Soviet Government until about 1930, though the latter was all the time aiding and expanding his laboratories, and bestowing on him many privileges and rewards. Equipment was added, new departments opened. A psychiatric clinic in Leningrad was dedicated for his use in the last years of his life. Koltushy, a village twenty miles to the north of Leningrad, was practically transformed into a genetic institution and a summer villa for Pavlov. How surprised I was when I returned there in 1933 after four years' absence to find the old simple wooden building, which had housed the laboratory in that quiet rural village of a few hundred peasants, forsaken. On the hill overlooking the lake where the cattle went at noon to drink, where Pavlov with his collaborators, Kupalov, Volborth, I and others had swum and fished, on the edge of the idyllic forest of birches with their slender silver trunks interlaced with a motley of delicate light green leaves where we had strolled in the mystic glow of the June white nights, alongside the gay flowering and magically scented fields—here a new city of laboratory buildings had arisen, dominating the village and hiding the forest. Around it were nicely planned walks and gardens in which I found Pavlov working several hours every day with spade and hoe. Instead of the slow train ride and the five mile walk which we formerly made travelling there from Leningrad, a direct bus service had been installed, taking an hour rather than half a day. (All this was typical of the other transformations occurring throughout the length and breadth of the Soviet Union.)

Other honours were heaped upon Pavlov in his fatherland and also abroad. On his eightieth birthday a large sum was given to the scientific work, the street leading to the Institute of Experimental Medicine was renamed for Pavlov and closed to outside traffic, and the village of Koltushy renamed Pavlovo.

The support to the Pavlovian Laboratories was increased from one million rubles in 1936 to two and one-half million in 1939, and the number of workers employed in the laboratory from 172 in 1937 to 357 in 1938 (official statement). All this began to modify Pavlov's point of view

toward the government. I first noticed the change in 1933 when I went to see Pavlov in his summer laboratory at Koltushy (now Pavlovo). When I asked Pavlov about his mollification, he said, perhaps facetiously, his heart could no longer stand the strain of extreme outbursts of rage. His son, Vsevolod, told me in 1935 the change came about by degrees.

So Pavlov's attitude toward the government changed from one of open hostility to tolerance and in the last two years of his life to definite friendliness. Pavlov was never half hearted about anything; he always burnt his bridges behind him. Though he had violently upbraided me in 1925 for stating in an interview what I considered marks of progress in the Soviet public health program ("I am nearly 80 and have never yet given an interview to a newspaper!"), in 1933 I found that he had no criticisms to make of the government and in 1935, he was unstinted in his praise of its efforts for science and international peace. Thus at the XV International Physiological Congress, held in Leningrad, in August 1935 he said:

> The XV International Congress of Physiologists is the first one to meet in our country. This is perfectly natural. Ours is a young physiology. The second generation of Russian physiologists is still at work, though it is nearing its end. We must consider I. M. Sechenov the father of our physiology; his lectures were not simply expositions of other peoples writings, he spoke as a specialist and created our first physiological school....

Speaking specifically on the importance of international gatherings of scientists and the threat of war:

> The second point that I wish to mention as having great significance for us is the special importance of such scientific gatherings for the younger generation of scientists. I know this beneficial influence from personal experience in the days of my youth. I remember well the influence that our previous congresses of naturalists and physicians had upon me. Our government spends great sums on scientific work and draws large numbers of the young generation into scientific research. Coming into personal contact with international representatives of scientific work should prove highly stimulating to them.
>
> Finally, point three. We all, as different as we may be, are now imbued and animated by an ardent interest in our common tasks in life. We are all bound together by a feeling of comradeship—in many cases, indeed, by ties of personal friendship. We are working, assuredly, for the rational and final unity of mankind. But if war were to break out many of us would become enemies precisely on our scientific plane, as has so often happened in the past. We would not want to meet as we do now. Even our scientific appraisal of each other would change.
>
> I can understand the grandeur of a war of liberation. Yet, it cannot be denied that war is essentially a bestial means of solving life's difficulties, a means unworthy of the human mind and its limitless resources.

And speaking at Ryazan, the place of his birth, when he revisited it on August 21, 1935:

> In our country the whole population honours science....I would not be mistaken, I think, in saying that this is to the credit of the government at the helm of my country.
>
> Formerly science was divorced from life and alienated from the people, but now I see it is otherwise—I see that the whole nation respects and appreciates science.

I raise my glass and drink to the only government in the world which could bring this about, which values science so highly and supports it so fervently—to the government of my country.

Pavlov's conversion was as complete as it was sincere. Though he had stated in 1924 that he would not give a frog's leg for the social experiment as it was being made, on August 20, 1935, he stated to the assembled physiologists in the Kremlin:

We, the leaders of scientific institutions, are really alarmed and uneasy over the question whether or not we are in a position to justify all those means which the government places at our disposal. As you know, I am an experimenter from head to foot.... Our government is also an experimenter, only on an incomparably higher plane. I passionately desire to live in order to see the victorious completion of this historical social experiment.[24]

A further conciliation and interest in the new government was shown in his letter of December 31, 1935, to the Stakhanovite miners:

All my life I have loved and still love mental and physical work but the second perhaps even more. Especially have I felt satisfaction when into the latter I carried some good problem, *i.e.*, united head and hands. Upon this road you are travelling. With all my heart I wish that you may advance far along this path, the only path that secures happiness for man.

Noteworthy in the original MS. (exhibited in 1939 at the World's Fair, New York), is the omission of the orthodox pre-revolutionary spelling, which Pavlov clung to as a gesture of defiance for a decade or more after the inauguration of the Soviets. This is an added evidence of the mollification of his feelings toward the Soviet Government.

Why this marked change in Pavlov's feelings toward the Soviet Government, which had from the beginning made him immune, allowed him freedom of speech and travel, supported his work, honoured him? Let it be said that Pavlov's change of heart was in no sense a recantation such as was forced upon Galileo by the Inquisition.

First, Pavlov, who always looked for facts, could not but be impressed by the enormous encouragement and impetus given to scientific workers all over the Soviet Union, and the increase in scientific personnel. During that period many foreign scientists were equally impressed by the progress of science and the social program in the U.S.S.R. Even as conservative a physiologist as Cannon, stated:

The leaders in the Soviet Union have supported warmly the plans which Pavlov developed and the purposes toward which he aimed. Furthermore, they are attempting to employ his methods practically in political and social education, in the education of abnormal individuals, in the re-education of criminals and prostitutes, and in the treatment of neuroses and other disorders commonly called mental. The outcome of these efforts to condition the cortex in new ways and thereby to bring about a reformation of conduct will be watched with supreme interest.[25]

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[24] As my purpose here is to give Pavlov's views rather than an evaluation of the Soviet political aims, all discussion of a controversial political nature is omitted.

[25] W. B. Cannon, "Ivan P. Pavlov," *Res. Bull. of the Soviet Union,* 1935.

Secondly, Pavlov's nature generally became less aggressive during the last decade of his life; he was more friendly and less vehement. This was a change in mood rather than in physical energy. In spite of his dislike for journeys, he crossed the ocean in 1929 to attend the XIII International Physiological Congress in Boston, where he received an ovation lasting many minutes—the longest I have ever seen in a scientific assembly. Here, in discussing operations with the famous brain surgeon Harvey Cushing, the latter said to Pavlov and me that he sometimes had to go to bed for the rest of the day after the strain of certain operations on the brain. But Pavlov at eighty could still operate four or five hours a day and then go out and play *gorodki* [26] for several hours. Whether drinking tea with his artistic friends Adelaide and Helen Hooker who had visited his laboratory in Leningrad, or with the sculptor Konenkov, or discussing conditioned reflexes at the Mayo Clinic, on the campus of Yale or of Harvard, he was everywhere welcomed and admired. In 1933 he was still spading and hoeing in his garden at Koltushy, and in 1935 he flew to London for the International Neurological Congress and back to Leningrad in time for the International Physiological Congress.

Pavlov died in harness, the hope of every ardent investigator. After the International Physiological Congress in Leningrad in August 1935, he worked actively in his several laboratories and clinics, holding conferences as usual with his collaborators. Six days before his death, February 21, 1936, he made his regular rounds through the laboratory. Gathering his assistants he said to them:

"Now we can and must go forward. The scientific material permits an immediate decision of the problem inscribed on the frontal of our Institute of Experimental Genetics. All of you physiologists should be acquainted with genetics in order to create an ideal type of the higher nervous activity of the dog—the strong, balanced, alert type—in order that we may use all of the experimental material for the investigation of the human being, striving to perfect the human race of the future."

Pavlov, though not introspective, was accustomed to study himself

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[26] *Gorodki* is an ancient game popular among the peasants of Russia, played with the same informality and ubiquity as "horseshoes" in this country. Two squares about the size of a small room are marked out on the ground some 60 to 80 feet apart, and into these are placed a number of six inch blocks of wood. The members of the opposing teams attempt to get all the blocks out of the square by throwing from a distance of 50 or 60 feet sticks about the size of baseball bats but much heavier. As soon as all the blocks are out, another formation is arranged to be knocked out, until a series have been set up, representing castles, fortresses, etc. The side which removes the blocks in the fewest number of strokes is the winner. The game requires considerable strength as well as some skill. Pavlov was a champion player until the age of 80, outlasting and outplaying all his youthful companions.

objectively, as in an experiment. When he became old, he frankly discussed with his pupils the effects of his own aging:

> You see, although age can not be considered pleasant—it brings many shortcomings with it—still, I want to benefit from it. And obviously, in connection with conditioned reflexes and the study of the nervous system, I constantly watch what age brings me. It is interesting that the same thing is happening to me that happens to all old men. That is natural. And you know that one of the first effects of age is loss of memory regarding impressions which were recently fresh.[27]

Following his operation for gallstones in 1927, Pavlov had written a paper on "Postoperative cardiac neurosis analysed by the patient Ivan Petrovitch Pavlov." In every illness he studied himself as he did his dogs in a laboratory experiment. The day of his death, February 27, 1936, while suffering a collapse, with pulse rate of 150, he summoned a neuro-pathologist to know whether his symptoms might not be interesting to science and to discuss them. Weak from the toxins and high fever of pneumonia, he said, "My brain is not working well, obsessive feelings and involuntary movements appear; mortification may be setting in."

For a while they talked of the scientific nature of these. For a few moments after this conversation he slept. It was only in the very last minutes of his life—the last half hour—that Pavlov ceased to make scientific observations on himself, as he quit the rôle of the great scientific observer and undaunted investigator. Finally he raised himself on his elbows in bed, and reaching for his clothes, with the same impatient, rushing energy that had for times without number tensed his every muscle and fibre, vibrated through him like a thunder-storm through a forest, he struggled to arise: "It is time to get up! Help me, I must dress!" That was the end. He fell back dead.[28]

These were his last words. Like many other heroes, his closing thoughts were of action.[29] In death as in life his spirit wrestled with the blind forces of Nature so often forced by this master experimenter to give up their secrets.

Earth has claimed what was hers, but to us there is left his example to work through endless generations of scientists.

"It is time to get up! Help me, I must dress."

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27 L. A. Andreyev, "The Great Teacher and Master of Science," *Scientific Monthly*, Vol. 45, 1937, p. 162.

28 Reported by Alexander Popovsky in an unpublished MS.

29 Mechnikov, the discoverer of phagocytosis, in his last hours was preoccupied with carrying on his investigations. "Remember your promise," he said to a collaborator, "you must dissect my body and observe the condition of the intestines. There you will undoubtedly find the cause."

CONDITIONED REFLEXES AND PSYCHIATRY

CHAPTER XLII

TRIAL EXCURSION OF A PHYSIOLOGIST IN THE FIELD OF PSYCHIATRY

(From *Archives Internationales de Pharmacodynamie et de Therapie,* 1930, in the volume dedicated to Gley and Heymans.)

RAISON D'ETRE OF PAVLOV'S STUDY OF PSYCHIATRY—MANIFESTATIONS OF SLEEP AND HYPNOSIS NOTED IN PSYCHOTIC PATIENTS, ESPECIALLY SCHIZOPHRENICS, ALSO IN ALCOHOLIC NARCOSIS—ATTITUDE TOWARD PATIENT.

AT THE present our material relates not only to normal activity but to pathology and to therapy. We have definite experimental neuroses in our animals (dogs) and in the same animals what is analogous to human psychoses, and we know their treatment. This was the *raison d'être* for my becoming thoroughly acquainted with psychiatry, of which practically no trace remained from my student medical days. Thanks to my medical colleagues I now have the opportunity to see different forms of mental disturbances. The first to come under my observation was schizophrenia. My attention rested particularly on the symptoms of apathy, dullness, immobility and stereotyped movements, and, on the other hand, playfulness, unconventionality and in general childish behaviour inappropriate to patients with such illnesses (hebephrenia and catatonia).

What is this from the physiological point of view? May not the physiologist group these phenomena, see in them a single general mechanism? Let us turn to the facts obtained from the conditioned reflex studies.

On the one hand the processes of excitation are constantly participating in the varied activity of the animal during the waking state, and on the other hand inhibition is ever appearing in the rôle of a guardian of the most reactive cells of the organism, the cortical cells of the cerebral hemispheres, protecting them against extraordinary tension of their activity when they meet with very strong excitations, securing for them necessary rest, after the usual daily work, in the form of sleep.

We have established beyond doubt the fact that sleep is inhibition spreading over all the hemispheres. We have also been able to study the intermediate phases between the waking state and complete sleep—the hypnotic phases. These phases appear to us, on the one hand, as different degrees of the extent of inhibition, *i.e.,* a more or less spreading of inhibition in the areas of the hemispheres themselves and also in different parts of the brain; and, on the other hand, as different degrees

of intensity of inhibition in the form of varying depths of inhibition at one and the same place. Naturally with the greater complexity of the human brain the hypnotic phenomena are considerably more varied in the human than in the animal. But it is possible that some of the hypnotic phenomena for one or another reason are more clearly marked in the animal, the more so because human hypnosis presents considerable variations depending upon the individual and the methods of hypnotization. Bearing in mind the whole symptom-complex of hypnosis, I shall in the future use the hypnotic phenomena observed in humans as well as in animals.

Studying the aforementioned schizophrenic symptoms I came to the conclusion that they are the expression of a chronic hypnotic state. Apathy, dullness, immobility, etc., are not necessarily manifestations of a hypnotic state unless I am able to find more justification for this view in the special symptoms.

First I shall mention the following facts. Apathy and dullness are generally expressed by the patient's failures to react to questions, as if he were completely insensitive. However if these questions are put to him very softly in very quiet surroundings he answers. This is a characteristic hypnotic phenomenon. . . . . It is to be regretted that for this very important symptom there is in the clinic no special name such as is given to other symptoms. In our animals this symptom is one of the most frequent signs of the beginning of hypnosis—met with in the so-called paradoxical phase in which the animal loses its reactions to strong stimuli, but reacts normally to the weak. In the well known case of a five-year sleep described by Janet, rapport with the patient was established only on this basis. Indeed the patient came out of the hypnotic state only at night when there was an interruption of the ordinary stimulations.

Negativism was manifested in the patients we analysed. Also in our experimental animals such negativism during the beginning of hypnosis was customary. With the conditioned food stimulus we feed the dog but he stubbornly turns away. Another interesting detail is especially marked in the inverse phase. When you remove the food from the dog he now attempts to get it. This can be repeated time after time. But when hypnosis disappears the dog greedily takes the food.

The analysis of the mechanism of this hypnotic symptom and of others I shall postpone until later, turning now to the evident facts of the hypnotic state.

One of the most extreme symptoms of schizophrenia with certain variations is *stereotypy*—a stubbornly continued repetition of the same movements. In several of our dogs too this is clearly observed. In the case of the conditioned food reflex, when the dog is fully awake, after

feeding he habitually licks for a short time the front part of the body, the front part of the chest and the front paw. During beginning hypnosis this licking is exceedingly prolonged, often lasting until the next feeding. Also other movements are repeated once they have been used by the animal in a certain way.

A common occurrence in schizophrenics is the so-called echolalia and echopraxia, *i.e.,* the pronunciation by the patient of the words of the one with whom he is conversing and the performance of all the movements of the person to whom he is giving his attention. This is a familiar phenomenon in a hypnotised normal subject, which, as I recall, occurs especially easily and frequently during hypnosis produced by the so-called passes.

A common manifestation in schizophrenics is catalepsy—the continued maintenance by the patient of any position of the body (which can be easily given to him without opposition of the muscles by another person) or of those positions which he himself takes under the influence of one or another temporarily acting stimulus. Again this is a symptom readily produced in normal hypnosis.

An obstinate symptom in some schizophrenics, appearing even in a definite form, is catatonia, *i.e.,* a tense state of the skeletal musculature strongly opposed to every change in a given position of a part of the body. This catatonia is nothing more than the operation of tonic reflexes thanks to which a hypnotised normal subject may be made as stiff as a board.

Finally here, to this group of every variation of central inhibition, it is necessary to relate even the symptoms of playfulness and foolishness observed especially in hebephrenics, and also a capricious and aggressive excitement accompanying the above-mentioned symptoms in other schizophrenics. All these phenomena bring strongly to mind the usual picture of the beginning alcoholic intoxication, and also the characteristic state seen during awakening and especially during the falling to sleep of children and young animals such as puppies. In these cases there is reason to think they are the result of a beginning general inhibition of the cerebral hemispheres, as a consequence of which the neighbouring subcortex is not only freed from its usual control, the constant inhibition from the hemispheres during the waking state, but even, on the basic mechanism of positive induction, there ensues an excitatory chaotic condition in all the centres. Hence during alcoholic narcosis there appears without cause now an unusual frolicsomeness and gaiety, now sensitiveness and tears, now rage, and during the falling to sleep of children every possible caprice. An especially characteristic picture is the drowsy child during the middle months of its first year, when may be seen on its face the kaleidoscopic play of varied expres-

sions—signs of a lack of organisation in childhood of the primitive subcortex. Thus the schizophrenic in certain phases and variations of its illness manifests this phenomenon now in long, now in short, periods.

After all the above cases one can hardly doubt that schizophrenia in certain variations and phases actually represents chronic hypnosis. That these variations and phases may continue for years is no refutation of this conclusion. If one may speak of a five-year sleep (case of Pierre Janet) and even of a twenty years' sleep (Petersburg case) why can there not be such continued hypnosis, the more so because these examples are more correctly called hypnosis rather than sleep?

What produces the chronic hypnosis of schizophrenia? What is its physiology and pathology? What is its course and outcome?

The ultimate basis of this hypnosis is, of course, a weak nervous system, especially a weakness of the cortical cells. This weakness can issue from different causes—hereditary and acquired. We shall not concern ourselves with these causes. But naturally such a nervous system on meeting with difficulties—most frequently in the critical physiological and socialising period—after an overwhelming stimulation inevitably enters into a state of fatigue. But fatigue is one of the chief physiological impulses to the creation of the inhibitory process as a protective process. Hence chronic hypnosis, representing inhibition in various degrees of extension and tension. Thus this state is, on the one hand, pathological, as it deprives the patient of his normal activity; on the other hand it is in its mechanism physiological, a physiological measure because it conserves the cortical cells against a threatening destruction consequent to an overwhelming task. We now have in the laboratory an amazing example of continued inhibition restoring the weak cortical cells for a certain period to normal activity. There is good reason to think that while the inhibitory process is acting the cortical cells remain uninjured; for they may return to a completely normal condition, they may recover from an extreme exhaustion. This according to contemporary terminology is only a functional illness. That this is actually so is confirmed by the following facts: Certain forms of schizophrenia, particularly hebephrenia and catatonia, *i.e.*, forms having a hypnotic character, according to Kraepelin, one of the greatest psychiatric authorities, result in a fair percentage of complete recoveries (catatonia to 15%), which is not true in certain other forms, particularly paranoia.

In conclusion allow me to make a therapeutic suggestion, hardly altogether sentimental and yet not professional. Although there has been no revolutionary progress in the treatment of the mentally ill from ancient times until our own, we have, I think, nothing to regret. The majority of the patients still retaining consciousness to a certain degree can sus-

tain on the one hand violent stimulations in the form of crises and extraordinary scenes, and on the other hand as direct force, but it is necessary to consider as useless an added threat to the weak cortical cells. Consequently we should as soon as possible think of such mentally ill as we do of other suffering patients, whose feelings of human dignity are not so severely tried.

CHAPTER XLIII

A BRIEF OUTLINE OF THE HIGHER NERVOUS ACTIVITY

(Article published in *Psychologies of 1930,* Clark University Press, Worcester, Mass., 1930.)

ANALYSIS OF THE BEHAVIOUR OF THE ORGANISM—THE ANATOMICAL SUBSTRATUM—ANALYSIS AND SYNTHESIS—PLAN OF STUDY OF THE HIGHER NERVOUS ACTIVITY—ORIGIN OF CONDITIONED REFLEX—INHIBITION—IRRADIATION AND CONCENTRATION—INDUCTION—RESULTS OF FATIGUE—TYPES OF DOGS—RECIPROCAL RELATION BETWEEN CORTEX AND SUB-CORTEX—EQUIVALENT AND PARADOXICAL PHASES—PHENOMENA OF HYPNOSIS—EFFECT OF INCREASED SEXUAL EXCITATION ON CORTICAL REACTIONS—RELATION OF DEFENCE REACTIONS TO FOOD EXCITATION.

At the present time, on the basis of nearly thirty years of experimentation done by myself with my numerous co-workers, I feel justified in asserting that the total external as well as internal activity of a higher animal, such as the dog, can be studied with complete success from a purely physiological angle, *i.e.,* by the physiological method and in terms of the physiology of the nervous system. The general factual material given below must serve as a proof of this assertion.

The activity of the nervous system is directed, on the one hand, towards unification, integrating the work of all parts of the organism, and, on the other, towards connecting the organism with the surrounding milieu, towards an equilibrium between the system of the organism and the external conditions. The former division of nervous activity may be called *lower* nervous activity in contradistinction to the latter part, which, because of its complexity and delicacy, may justly take the name of *higher* nervous activity, usually called animal or human behaviour.

The chief manifestation of higher animal behaviour, *i.e.,* its visible reaction to the outside world, is motion—a result of its skeleto-muscular activity accompanied to some extent by secretion due to the activity of glandular tissues. The skeleto-muscular movement, beginning on the lower level with the activity of separate muscles and of small groups of muscles on the upper, reaches a higher integration in the form of locomotor acts, in the equilibration of a number of separate parts, or of the whole organism in motion, with the force of gravity. Moreover, the organism, in its surrounding milieu, with all its objects and influences, performs special movements in accordance with the preservation of the organism and of its species. These constitute reactions to food, defence, sex, and other motor and, partly, secretory reactions. These

special acts of motion and secretion are performed, on the one hand, with a complete synthesis of the internal activity of the organism, *i.e.*, with a corresponding activity of internal organs for the realisation of a given external motor activity; on the other hand, they are excited in a stereotyped way by definite and not numerous external and internal stimuli. We call these acts *unconditioned,* special, and complex *reflexes.* Others attribute to them various names: instincts, tendencies, inclinations, etc. The stimuli of these acts we shall call correspondingly *unconditioned stimuli.*

The anatomical substratum of these activities is to be found in the subcortical centres, the basal ganglia nearest to the cerebral hemispheres. These unconditioned, special reflexes constitute the most essential basis of the external behaviour of the animal. However, alone, these responses of the higher animal, without any additional activities, are not sufficient for the preservation of the individual and the species. A dog with extirpated cerebral hemispheres may manifest all these responses and yet, abandoned, he unavoidably perishes in a very short time. In order that the individual and the species be preserved, a supplementary apparatus must, of necessity, be added to the basal ganglia—the cerebral hemispheres. This apparatus makes a thorough analysis and synthesis of the external milieu, *i.e.,* it either differentiates or combines its separate elements in order to make of them or their combinations numberless signals of basic and necessary conditions of the external milieu, towards which is directed and set the activity of subcortical ganglia. In this manner the ganglia have the opportunity to adjust, with fine precision, their activity to external conditions—finding food where it may be found, avoiding danger with certainty, etc. Moreover, a further important detail to be considered is that these numberless external agents, now isolated and now combined, are not permanent but only temporary stimuli of subcortical ganglia, in accordance with the incessant fluctuations of the environment, *i.e.,* only when they signal correctly the fundamental and necessary conditions for the existence of the animal, which conditions serve as unconditioned stimuli of these ganglia.

The detailed analysis and synthesis produced by the hemispheres, however, is not limited to the external world. The internal world of the organism with its organic transformations is also subjected to similar analysis and synthesis. To this analysis and synthesis are especially subjected—and to a very high degree—phenomena taking place in the skeleto-muscular system, such as muscular tension of separate muscles and of their numberless groupings. And some of these most delicate elements and moments of the skeleto-muscular activity become stimuli in the same way as do those coming from external receptors, *i..e.,* they may

temporarily become connected with the activity of the skeleto-muscular system itself as well as with any other activity of the organism. In this manner, by means of special unconditioned reflexes, the skeleto-muscular activity realizes a multiform and subtle adaptation to continually changing environmental conditions. It is by means of such a mechanism that we realise our most minute, acquired through practice, motions such as those of our hands, for example. Here also belong movements of speech.

The cerebral hemispheres, due to their exceptional reactivity and flexibility, make it possible for the strong, although naturally inert, subcortical centres, through a mechanism as yet not known, to react by appropriate responses to extremely weak fluctuations of the environment.

Consequently, in the higher nervous activity of the animal, in its behaviour, three fundamental topics must be studied: 1) unconditioned complex special reflexes, the activity of the basal ganglia, as a foundation for the external behaviour of the organism; 2) the activity of the cortex; 3) method of connexion and interaction of these ganglia and the cortex.

It is the second topic that is now being studied by us most thoroughly and in fullest detail, and for this reason, the material treated in this outline will be mostly related to it, and then we shall add our first attempts at studying the third topic.

The greater part of unconditioned special complex reflexes is more or less known (I am referring to the behaviour of the dog). Among these are, first, individual reflexes such as those related to food, pugnacity, active and passive defence, freedom, investigation, and play; secondly, species reflexes such as sex and parental reflexes. But are these all? Furthermore, we know little or nothing about the methods of their direct excitation and inhibition, their relative strength and interaction. Obviously, one of the important problems of the physiology of the higher nervous activity is procuring higher animals (such as dogs) with extirpated hemispheres, but with intact basal ganglia, in good health, and having a sufficiently long span of life, to enable us to answer the above-stated problems.

As for their connexion with the hemispheres, we know the fact, but we do not satisfactorily visualise its mechanism. Let us take the ordinary special food reflex. It consists in a movement in the direction of an external object, serving as food for a given animal, in the introduction of it into the beginning of the digestive tract, and its moistening by the digestive juices. What the initial stimulus of this reflex is, we do not know definitely. All that we know is that an animal (such as a dog) with extirpated cerebral hemispheres, a few hours after he has been

fed, emerges from his state of drowsiness, begins to move and ramble about until the next feeding. Then he falls asleep again. Obviously, here we see motion related to food, but entirely indefinite, not reaching any goal. Moreover, there is a secretion of saliva while the animal is moving. Nothing definite in the external world provokes either this food motion or this secretion. It is an internal excitation.

In an animal with intact hemispheres, the matter is entirely different. A mass of external stimuli may definitely provoke a food reaction, and direct the animal to the food with precision. How does this take place? Obviously, the phenomena of nature serve as food signals. And this can be proved very easily. Let us take any natural phenomenon that has never had any relation either to food motion or to food secretion. If this phenomenon precedes the act of eating, once or several times, it will later on provoke a food reaction; it will become, so to speak, a surrogate for food—the animal moves toward it and may even take it into its mouth, if the object is tangible. Therefore, when the subcortical centre of the food reflex is excited, all other stimuli reaching simultaneously the finest receptors of the hemispheres seem to be aimed toward that centre, directly or indirectly, and with it may become firmly connected all stimuli falling at that moment on the most delicate receptors of the cerebral hemispheres. Then takes place what we have called a *conditional reflex, i.e.,* the organism responds with a definite complex activity to an external excitation to which it did not respond previously. This excitation originates, undoubtedly, in the hemispheres, for the fact just described no longer occurs in animals after they have been deprived of the cerebral hemispheres. What can we say further about this fact? Since such a temporary connexion, under the same conditions, may be formed with every one of the special centres of the nearest subcortical ganglia, one must admit, as a general phenomenon on the higher level of the central nervous system, that every strongly excited centre in some manner attracts towards itself every other weaker excitation reaching the system simultaneously. In this manner, the point of application of this excitation for a definite time under definite conditions becomes more or less firmly connected with that centre (the law of the closing of nervous paths—association). An essential detail of this process is that a certain precedence in time on the part of the weaker stimulus in regard to the stronger one is necessary for the formation of the connexion. If, while a dog is being fed, an indifferent stimulus is added, there is no formation of any significant and stable conditioned food reflex.

The conditioned reflex may serve as an excellent object for the study of the nature of individual cortical cells as well as of the processes taking place in the whole cortical cellular mass, since the excitation of

the cerebral cortical cells serves as an initial stimulus for the conditioned reflex. This study made us acquainted with a considerable number of laws concerning the activity of the cerebral hemispheres.

If in conditioned food reflexes we should start consistently from a food stimulus of definite strength (18-22 hours after the usual satisfying feeding), the fact of a definite relationship between the effect of the conditioned stimulus and the physical strength of that stimulus becomes clear. The stronger the conditioned stimulus, the greater the energy simultaneously entering the hemispheres, the stronger is the effect of the conditioned reflex, other things being equal, *i.e.,* the more energetic is the motor food reaction, and the more abundant the flow of saliva, which we customarily utilise in measuring the effect. As one may judge from certain experiments, this relationship between the effect and the intensity of the stimulus must be quite exact (the law of the relationship between the magnitude of the effect and the strength of the stimulation). There is always, however, a limit beyond which a stronger stimulus not only does not increase but tends to decrease the effect.

Likewise in the phenomena of summation of conditioned reflexes we again meet with the same limits. In combining a number of weak conditioned stimuli, one may often observe their exact arithmetical sum. In combining a weak stimulus with a strong one, one observes a certain increase in the resulting effect, within a certain limit; whereas in combining two strong stimuli the effect, passing the limit, becomes less than that of each of the components (the law of the summation of conditioned stimuli).

Besides the process of stimulation, the same external conditioned stimulus may elicit in cortical cells an opposite process—a process of inhibition. If a conditioned positive stimulus, *i.e.,* producng a corresponding conditioned reaction, is continued alone for a certain length of time (minutes), without being accompanied any longer by its unconditioned stimulus, then the cortical cell corresponding to this stimulus necessarily passes into a state of inhibition. And this stimulus, as soon as it is systematically applied alone, conditions in the cortex not a process of stimulation but a process of inhibition; it becomes a conditioned inhibitory negative stimulus (the law of transition of the cortical cells into a state of inhibition).

From this property of the cell are derived extremely important consequences for the physiological rôle of the cortex. Thanks to it, a working relationship is established between the conditioned and the corresponding unconditioned stimuli, in which the former serve as a signal for the latter. As soon as the conditioned stimulus is no longer accompanied by an unconditioned stimulus, *i.e.,* signals incorrectly, it

loses its stimulating effect, although only temporarily, spontaneously reappearing sometime later. Also, in other cases when the conditioned stimulus is not accompanied by an unconditioned stimulus, either under constant definite conditions or some considerable time after the beginning of its action, such a stimulus proves to be consistently inhibitive in the former case, and in the latter case inhibitory during the first period of the action of the conditioned stimulus. In this manner, due to the developing inhibition, the action of the conditioned stimulus as a signal conforms to the minute conditions of its physiological rôle, without producing unnecessary work. Moreover, on the basis of the developing inhibition, there takes place in the cortex the very important process of the minute analysis of the external excitations. At the beginning, every conditioned stimulus has but a general character. If, for example, a conditioned stimulus is made of a definite tone, several of the neighbouring tones will elicit the same effect without any preliminary training. This applies to all other conditioned stimuli. However, if the original stimulus is consistently accompanied by its corresponding unconditioned stimulus, whereas the stimuli related to the original stimulus are repeated alone, then in the latter case a process of inhibition takes place. They become inhibitive stimuli.

Thus, we may reach the limit of analysis of which a given animal may be capable, *i.e.,* most minute natural phenomena may become special stimuli for a definite activity of the organism. We may think that by the same process by which connexions are formed between cortical cells and subcortical centres connexions are also formed between the cortical cells themselves. The excitations produced by phenomena taking place simultaneously in the outside world are thus complex. These complex excitations may become, under corresponding conditions, conditioned stimuli, and be differentiated by means of the just-indicated process of inhibition from other closely related complex stimuli.

The processes of excitation and inhibition, originated at definite points of the cortex under the influence of corresponding stimuli, necessarily irradiate over a large or smaller area of the cortex, and then again concentrate in a limited space (the law of irradiation and concentration of nervous processes).

Above, we have just mentioned the initial generalisation of all conditioned stimuli—a result of irradiation of the excitations reaching the hemispheres. The same thing takes place, at first, in the case of inhibitory processes. When an inhibitory stimulus is applied and stopped, inhibition may be observed for some time in other and usually very distant centres of the cortex. This irradiated inhibition, as well as excitation, becomes more and more concentrated, especially under the influence of juxtaposition with an opposite process, *i.e.,* the applied processes

limit each other. There is even an indication of the existence in the space between them of a neutral point. In the case of a well-elaborated inhibitory stimulus, one may notice in many dogs a strict concentration of inhibition at the point of excitation, since, simultaneously with the inhibitory stimulus, the applied positive stimuli produce a full, and often even a greater, effect, whereas the irradiation of inhibition begins only after the stimulation is stopped.

Parallel with the phenomena of irradiation and concentration of excitation and inhibition occur, interwoven with these, phenomena of mutual induction of opposite processes, *i.e.*, intensification of one process by another taking place either in succession at the same point or simultaneously at two neighbouring points (the law of reciprocal induction of nervous processes). The matter, probably a temporary phase, appears very complicated. When either a positive or an inhibitory stimulus (especially the latter) destroys a given equilibrium in the cortex, there seems to pass over it something like a wave with a crest, the positive process, and with a trough, the inhibitory process, a wave that gradually flattens out, *i.e.*, what takes place is an irradiation of processes with the necessary participation of their mutual induction.

Of course, it is not always possible to give an account of the physiological rôle of the just-described phenomena. For example, the initial irradiation of every new conditioned stimulus may be interrupted as though every external agent which became a conditioned stimulus, in reality, under the varying conditions of the environment, were subjected to fluctuations not only with respect to its intensity but to its quality. Mutual induction must lead towards the intensification and fixation of the physiological significance of every single stimulus, whether positive or negative, which indeed has been observed in our experiments. However, the spreading of inhibition all over the hemispheres, lasting for a considerable length of time, when it is produced by a definite agent at a definite point, still remains incomprehensible. Is it due to a defect, or the inertia of the apparatus, or is it a definite phenomenon, the biological meaning of which still escapes us (which, of course, is quite possible)?

As a result of the indicated work, the cortex presents a grandiose mosaic, upon which are distributed, at a given moment, a huge number of points of application of external excitations, now stimulating, now inhibiting, the various activities of the organism. Since, however, these points are in a definite reciprocal functional relationship, the cerebral hemispheres are, at any given moment, a system in a state of dynamic equilibrium, which one might call a stereotype. Fluctuations within the determined limits of this system are a relatively easy matter. But the inclusion of new stimuli, especially all at once and in large num-

bers, or only replacing a large number of old stimuli, represents a considerable nervous process, a task which is beyond the strength of many nervous systems, ending in the bankruptcy of the system, expressing itself in a refusal for some time to accomplish normal work.

Every living working system, as well as its separate elements, must rest and recuperate. Moreover rest periods of such reactive elements as the cortical cells should be carefully observed. Indeed, in the cortex, the regulation of work and rest is realised to the highest degree. The work of every element is regulated with respect to its intensity and its duration. We have seen already how an excitation of the same cell, lasting only a few minutes, leads towards the development in it of a process of inhibition, which decreases its work and finally stops it altogether. There is another, no less striking case of preservation of the cell—the case of a strong external stimulus. For every one of our animals (dogs) there is a maximum stimulus, a limit of harmless functional strain, beyond which begins the intervention of inhibition (the law of the limit of intensity of stimulation). A stimulus, the intensity of which is beyond that maximum, instantly elicits inhibition, thus distorting the usual rule of the relationship between the magnitude of the effect and the intensity of excitation; a strong stimulus may produce an equal and even a smaller effect than a weak one (the so-called *equivalent* and *paradoxical* phases).

Inhibition, as already stated, has a tendency to spread, unless it meets with a counteraction in the conditions of a given environment. It expresses itself in phenomena of either partial or total sleep. Partial sleep is, evidently, the so-called *hypnosis*. We were enabled to study upon dogs the various degrees of extensiveness as well as of intensiveness of hypnosis, which ultimately passed into complete sleep, when stimulating influences were insufficient.

The delicate apparatus of the cerebral hemispheres was found, as one might expect, very different in various specimens of the same species (our dogs). We had good reasons to distinguish four different *types* of cerebral hemispheres: two extreme ones, the excitable and the inhibitory; and two central, balanced ones, the calm and the lively. In the former two, one is dominated by the process of excitation, and the other by the process of inhibition. In the latter two, the two processes are more or less balanced. Moreover, we are considering here the amount and the intensity of the working capacity of the cells. The cells of the excitatory type are very strong and capable of developing, without too much labour, conditioned reflexes to very strong stimuli. For the inhibitory type, this is impossible. The central types probably (this still remains to be established) are endowed with cells of moderate strength. One must think that this difference determines that an excitable type

is not endowed with a correspondingly sufficient inhibitory process, whereas the inhibitory type lacks in sufficient stimulating processes. In the central types, both processes are almost equally strong.

Such is the work of the large hemispheres in a normal healthy condition. However, their work being of extreme delicacy, they may very easily pass into a morbid, pathological state, especially in cases of extreme unbalanced types. The conditions for the transition into a morbid state are quite definite. Two of these are well known. These are: very strong external stimuli and the collision of the excitatory and inhibitory processes.

Strong stimuli are especially apt to become harmful agents for a weak inhibitory type, which, under their influence, passes into a state of complete inhibition. The collision of opposite processes, on the other hand, results in all sorts of disorders in both the strong and weak types. The former loses altogether the ability of inhibition, whereas in the latter the excitatory process is considerably weakened. Among the pathological phenomena an especially interesting one is that the disorder may be limited to a single, very small spot of the cerebral hemispheres, which undoubtedly proves its mosaic structure. Recently, it was possible, to a certain degree, to reproduce in the laboratory the analogue of the usual war neurosis, when the patient with corresponding cries and movements lives through terrible war scenes while falling asleep or in a state of hypnosis.

After we have become acquainted with the activity of the cortex of the cerebral hemispheres, let us turn to the subcortical centres in order to see of what significance they are, in turn, to the cortex.

Subcortical centres are inert to the highest degree. It is a well-known fact that a dog with extirpated hemispheres does not respond to a very large number of stimuli from the external world to which a normal animal reacts consistently and quickly. This refers to both the quality and the intensity of external stimuli. In other words, both the external and internal world are extremely limited for dogs with extirpated cerebral hemispheres. Similarly, subcortical centres are deprived of their reactive and labile inhibitions. Whereas, during the activity of the hemispheres, inhibition arises frequently and quickly, the subcortical centres, being very strong and resistant, do not show this tendency. Here are a few examples. The investigatory (orienting) reflex to weak and moderate intensities of external stimulations, in the case of a normal dog, disappears by virtue of inhibition after three to five repetitions, and sometimes sooner. In dogs with extirpated hemispheres, there is no inhibition when sufficiently strong stimuli are repeated. In the case of a hungry dog, the conditioned food reflex, originating in the hemispheres, is usually extinguished in a few minutes, even to the extent of

refusing food; with an equally hungry dog, the unconditioned food reflex (eating after the dog has had its oesophagus isolated from the stomach, *i.e.,* when food does not reach the stomach) continues from three to five hours and stops because of the probable exhaustion of the masticating and swallowing muscles. The same applies to the reflex of freedom, *i.e.,* to the reaction of struggling when the movements of the animals are hampered. Whereas a normal dog can easily and almost consistently restrain such a reflex, in a dog with extirpated hemispheres such restraint is impossible. The latter, while taken out from its cage for feeding, manifested daily for months and even years a furious aggressive reaction.

Cerebral hemispheres, in some manner, overcome the described inertia of the subcortical centres with respect both to excitation and inhibition, since in a large number of cases the hemispheres must stimulate the organism to activity or stop one or another of its activities through the intermediary of subcortical centres. In what manner do weak external and internal stimuli, insufficient for the direct excitation of these centres, excite them through the mediation of the hemispheres? To this, physiology gives no definite answer. Perhaps a summation of a new excitation with the traces of an old one takes place in the cerebral hemispheres, an accumulation of excitations; perhaps a certain rôle is also played by the usual irradiation of the excitation over the cortical tissue, etc.? No clearer is the rapid inhibition of the subcortical centres by the hemispheres when the latter are weakly stimulated. Of course, the simplest case is when the hemispheres gradually accumulate inhibitions, which become strong enough to overcome the direct strong excitation of the subcortical centres. Indeed, we saw in our experiments more than once that long applied and intensive inhibition in the hemispheres may strongly hold back the effect of the unconditioned stimulus. Thus, food which is already in the mouth may not provoke salivation for a long while; thus, also, was it frequently observed that chronic excitation of the cortex, following an operation, totally inhibits the activity of the subcortical centres for a considerable period of time: the animals become completely blind or deaf, whereas animals totally deprived of the hemispheres react, although in a limited way, to a strong visual stimulus and especially distinctly to an auditory stimulus. One may also easily imagine that the cerebral hemispheres excited to a certain tonus throughout their whole mass, under the influence of a number of excitations reaching them, exert an inhibiting action upon the subcortical centres, according to the law of negative induction, and thus lighten for themselves every special additional inhibition of these centres. In this manner, the cerebral hemispheres not only analyse and synthesise very subtly the external and the internal world of the ani-

mal, for the benefit, so to speak, of the subcortical centres, but continually correct their inertia. Only then does the activity of the subcortical centres, so important for the organism, find itself in the proper relationship to the environment of the animal.

However, the influence of the subcortical centres on the cortex is by no means less than that of the cortex on the subcortex. The active state of the hemispheres is being continually maintained by excitations coming from subcortical centres. This point is now being carefully studied in laboratories under my direction, and especial significance ought to be attributed to experiments, being carried out by Dr. V. V. Rikman, which I shall now describe in detail.

If we start from the habitual sufficient feeding of the dog, during which the law of the relationship between the magnitude of the effect and the intensity of excitation manifests itself, and if we increase the animal's excitability to food, either by decreasing the daily ration or by lengthening the interval between the last feeding and the beginning of the experiment, or merely by making the food more tasty, we shall surely observe very interesting modifications in the magnitude of the conditioned reflexes. The law of the dependence of the magnitude of the effect and the intensity of excitation becomes abruptly changed; now both strong and weak stimuli are comparable in their effects, or, what happens even more often, strong stimuli produce a smaller effect than the weak ones (the equivalent and paradoxical phases), the strong stimuli decreasing and the weak ones increasing their effects (equivalent and paradoxical phases on a high level). Excitable dogs with strong cortical cells show an increase in their response to strong stimuli under indicated conditions, but the increase of the response to weak stimuli is considerably greater so that, eventually, we reach both the equivalent (more often) and paradoxical phases.

Let us now take a reverse case. Let us decrease the excitability to food. In general, the result appears to be the same, *i.e.*, the same equivalent and paradoxical phases; the effect of strong stimuli again becomes equal to that of the weak ones or even becomes smaller. There appears, however, an essential difference. This time, the effect of weak stimuli either remains unchanged or decreases towards the end of the experiment after the application of strong stimuli (equivalent and paradoxical phases on the low level). The results reached are such that the dog under strong stimulation refuses to take food, and takes it only under a weak stimulus. Moreover, with excitable dogs, a state of restlessness may be observed; the dog whines, moves to and fro in the stand. This state, on the whole, resembles the approach of an hypnotic state (a struggle between excitation and inhibition).

How are we to understand the described facts? Since in both cases inhibition dominates the strong stimuli and since the aroused inhibition irradiates and may for the second time influence weak stimuli—which could be observed in the experiments, especially with a lowered excitability to food—it was decided to carry out the same experiments with the exclusion of strong stimuli. A strict rule was thus manifested: the effect of weak stimuli runs parallel with the increase or decrease of the excitability to food, *i.e.*, increases with the increase of that excitability and drops with its decrease. In this manner, the whole phenomenon was simply explained as the spreading of that excitability from the subcortex to the cortex.

But what happens when we use strong stimuli? Let us begin with the first case. When the excitability to food is increased, the effect of strong stimuli is either slightly increased, as compared with the increase in the effect produced by the weak stimuli, or, more often, is decreased, while this decrease becomes very abrupt through repeated applications of these stimuli during the experiment. It becomes quite clear that with the increase of the excitability of the cortical cells—which is indicated by the heightened effect of weak stimuli—the formerly strong stimuli become maximal, if they were not already such, whereas the formerly maximal stimuli become ultramaximal. An inhibition develops then against the latter, which become dangerous in the sense of a functional overstrain of the cell, according to the law of the limit of the intensity of excitation. This is exactly similar to what happens in ordinary experiments when excessively strong stimuli do not give a greater but a smaller effect in comparison with strong stimuli, which are below the limit of intensity. What in the latter case becomes an absolute intensity of the stimuli, takes place in the former case at the expense of an increase of instability (lability) of the cell. That all this is interpreted correctly may be proved also by the fact that, with a further increase of excitability to food, the formerly weak stimuli reach a limit, become ultramaximal, and then provoke an inhibition.

Yet how are we to understand the case of inhibition of strong stimuli when the excitability to food is lowered? Whence and why does inhibition now arise? Obviously, we are dealing here with a more complicated fact. Yet, it seems to me, it can be satisfactorily understood if we connect it with the following well-known facts.

However variegated is life, in general, yet every one of us, as well as the animal, must have a large number of stimuli which are always the same *i.e.*, those which fall always upon the same elements of the cortex. These elements then, sooner or later, must reach a state of inhibition, overtaking the mass of the hemispheres and leading to a state of hyp-

nosis and sleep. We see this constantly in our own life as well as in our experiments with dogs, especially when they are isolated from a variety of stimuli. For this reason, we often have to struggle with a handicap coming from a developing hypnosis. The chief counteraction to this hypnotisation comes, of course, from unconditioned stimuli applied by us in our experiments, mostly from periodical partial feedings. Therefore, by decreasing the excitability to food, we give the upper hand to hypnotising excitations and should obtain a state of hypnosis, which actually takes place, as was shown above.

This is not all. We must still explain why, during the hypnosis, the strong stimuli are among the first to be subjected to inhibition, and why the equivalent and paradoxical phases take place. In this case, we may take advantage of the following observations, in which the mechanism of the phenomena is more or less clear. In our experiments, we became acquainted long ago with the fact that at the beginning of hypnosis there is a divergence between the secretory and the motor components of the food reflex. Under the artificial conditioned stimulus as well as under a natural excitation (sight and odour of food), the saliva flows profusely, yet the dog does not take the food, *i.e.*, the inhibition developing in the hemispheres somehow dominates all of the motor area. Why? We thought, because this part of the hemispheres worked most during the experiments, since the dog had to maintain a state of alertness. This supposition received considerable support from further observations. At the very first sign of hypnotisation, the dog under a conditioned stimulus turns towards the food. When the food container is offered, the dog follows it by movements of its head when the container is raised or lowered or moved from side to side, but it cannot take any food and merely opens the mouth a little, whereas the tongue very often hangs motionless from the mouth as though it were paralysed. And only after continued excitation through the offered food does the mouth open wider, and eventually the animal takes some food into its mouth, but even then the chewing act is interrupted a few seconds by curious jerks until finally begins energetic, greedy eating.

When hypnotisation is further developed, the animal merely follows the food by moving its head, but does not even open its mouth. A little later, it merely turns with its whole body toward the food, and finally there is no other motor reaction whatsoever.

There is an obvious sequence in the inhibition of various parts of the motor area of the cortex corresponding to their work in these experiments. During the experiment with food reflexes, most work is being done by the masticating muscles and the tongue, then by the muscles of the neck, and finally by the body. It is in this order that they are over-

taken by the inhibitory process. Therefore, the part that worked most is first subjected to the effect of the spreading inhibition. There is a complete coincidence in that the exhaustion in a cortical cell consistently leads to the appearance in it of an inhibitory process. Thus, inhibition, irradiating from cells continually excited by the conditions of the experiment, is summated with the inhibitions proper of the working cell, and here it reaches its maximal intensity.

Such an interpretation of phenomena may be justifiably transferred to the case, analysed by us, of the decrease in the excitability to food. The hypnotising effect of the environment becomes more important when the excitability to food is lowered, naturally is felt first in the cells of the conditioned excitors which worked most energetically under the influence of stronger stimuli.

Therefore, subcortical centres, in a greater or lesser measure, determine the active state of the hemispheres and so change, in a multiform manner, the relation of the organism to the surroundings.

Also some of our experiments (the most recent one being somewhat artificial in form, it is true) corroborate the important significance of subcortical centres in the activity of the cortex.

Given below are D. I. Soloveychik's experiments on the influence of the ligation of the seminal duct and the grafting of a small piece of a seminal gland from a young animal (done simultaneously) upon conditioned reflex activity.

The experiments were first performed upon a dog known for a long time (five to six years) to have a very weak cortical tissue. After the collision of the excitatory with the inhibitory process, the dog showed symptoms of neurosis, lasting five weeks. At first, all the conditioned reflexes disappeared; then they gradually reappeared, but showed a distorted relationship between the intensity of excitation and the corresponding effect; and only little by little, through a series of phases, was the normal activity of the cortex re-established. Later on, the conditioned reflex behaviour of this dog became considerably weaker. The effects of the conditioned stimuli became smaller and smaller. It became necessary to increase by various methods the excitability to food. The formerly strongest stimulus now ranked lowest from the point of view of its effectiveness. All stimuli sharply declined in effect after a single repetition. A change in the usual order of conditioned stimuli was followed by the disappearance of all conditioned reflexes for several days.

Two or three weeks after the operation, the situation was radically changed. All the reflexes increased considerably in magnitude. The normal relationship between the intensity of the stimulus and that of

the response was re-established. Through repetition, the reflex no longer decreased, nor did a change in the order of stimuli have any deleterious effect. Even a collision of the excitatory and the inhibitory processes, repeated more than once, remained now without the slightest effect upon the activity of the cortex. This condition of the dog lasted for two or three months, and then it rapidly returned to the state in which it was before the operation. A similar operation performed upon the second seminal gland of the same dog was accompanied by a similar result. The same phenomena occurred also with another dog.

Thus, the processes which took place in the seminal gland, both nervous and chemical, manifested themselves very vividly in the activity of the cortex. However, to such questions as: in what manner? directly or by the intermediary of subcortical centres? by a nervous path or a chemical method, or by a method of summation?—no precise answer can be given until further analysis. Of course, similar questions, relating to the effect upon the cortex of the excitability to food, are as legitimate. However, taking into consideration the effect of both external and internal unconditioned stimuli of the subcortical centres, obviously directed towards them, judging from the considerable duration of their action (which would be impossible for cortical cells) and also turning our attention to the extraordinary intensity of the activity of these centres after the control over them by the hemispheres had been weakened, or eliminated, we may consider that very probably the above-described modifications in the activity of the cortex are secondary, for the greater part, at least, and not primary, *i.e.,* they take place under the influence of modifications in the excitability of the subcortical centres.

Finally, I shall also describe the related experiments of G. P. Konradi. By the use of three tones of the same musical instrument, three conditioned reflexes were formed in a dog reacting to three unconditioned stimuli: to acid with the low tone, to food with the medium tone, and to a strong electric current, applied to the skin of the shin, with the high tone. When these were fully established, the following interesting phenomena could be observed. First, with the low and medium tones a defensive reaction could be observed at the beginning of their action, and only after continuation of the excitation did it change into either the acid or the food reflex. Secondly, intermediate tones, which were also tried, were found to be related mostly to a defensive reaction. The regions of generalized "acid" and "food" tones were very limited. The whole diapason of tones, both beyond the limits of our extreme tones, and in the interval between the low and medium tones, evoked a defensive reaction. Since the relative physical strength of conditionally acting

tones could not determine such differences between them, these must be attributed to differences of intensity in the stimulation of the subcortical centres.

In conclusion, it may be said that our experiments, as related above, are, of course, only the first tentative experimental attack on one of the most important physiological questions of the interaction of the cortex and the nearest subcortical centres.

CHAPTER XLIV

CONTRIBUTIONS TO THE PHYSIOLOGY AND PATHOLOGY OF THE HIGHER NERVOUS ACTIVITY

(Read at the Institute for Perfection of Doctors, January 12, 1930.)

EFFECT OF PROGRESSIVE SECTIONS IN THE CENTRAL NERVOUS SYSTEM—PURPOSE OF CONDITIONED REFLEXES—INDUCTION AND ACTION OF CORTEX AS MOSAIC—ANALOGIES TO HYSTERIA AND NEURASTHENIA—PATHOLOGICAL CONDITIONS—CATALEPSY—FUNCTION OF SUBCORTICAL GANGLIA—SCHIZOPHRENIA—PHYSIOLOGY AND PSYCHOLOGY.

ESTEEMED Comrades! Appearing here among doctors I shall dwell chiefly on those of our investigations directly related to medicine. However before I proceed with these questions of medical interest I shall give some explanation of the underlying physiology, reminding you of facts not yet in the textbooks.

As you know, I and my collaborators are studying the behaviour of the higher animals. What is the behaviour of the human or of the animal? It is the most delicate correlation of the organism with the surrounding medium, understanding this in the widest sense of the word. Until the end of the last century these correlations of the organism with the surroundings was called the psychical activity of the animal organism to which there was no approach from the side of physiology. On the basis of almost thirty years of experimentation conducted by me and my many collaborators I can now with complete justification say that all the external activity of the higher animal such as the dog, as well as its internal activity, can be successfully studied physiologically, by the methods and in the terms of the physiology of the nervous system.

You as physicians know that the action of the nervous system is directed on the one hand toward the unification, the integration of the work of all parts of the organism, but on the other hand, toward the union of the organism with the external world. The activity concerned with the internal world of the organism may be termed the lower nervous activity, in contrast to the other adjustments of the organism to the external world to which is reserved the phrase higher nervous activity. Thus the two expressions, behaviour and higher nervous activity, correspond. Behaviour, understood as the higher nervous activity, can now be subjected to a purely natural scientific analysis, the result of which I shall give you briefly.

What does the higher nervous activity consist of? You know that

the fundamental form of activity of the nervous system is the response —a lawful union of some agent of the external or internal world by means of the receptor nervous apparatus, the nerve fibres, the nerve cells and the terminals with one or another activity of the organism. These responses gradually grow in complexity from below upward, from the lower segments of the nervous system, and attain the utmost intricacy in the cerebral hemispheres. The chief external manifestation of an activity is movement—the result of the activity of its skeleto-muscular system with a certain participation of the secretion. By the simplest physiological experiments we may elaborate a complication of the reflex skeleto-muscular movements in proportion to their proximity to the higher parts of the central nervous system.

From an isolated section of the spinal cord you can get only a few responses—in the case of the skeleto-muscular work, the activity of separate muscles and a few groups of muscles. If your section is directly under the thalamus, so that the extirpated part consists of the cerebral hemispheres and the thalamus, the animal manifests very intricate physiological functions such as standing and walking which necessitate a high degree of integration of the skeleto-muscular activity.

Making the cut still higher, extirpating only the cerebral hemispheres, you have very complex reflexes for the purpose of special movements to preserve the whole organism and its form. Such a dog arranges his internal activity well, and thanks to this he can remain healthy and live very much like a normal animal. He tries to get food, defends himself from every harm, does not tolerate a limitation of his movements; the orienting reflex is clearly present. These complex acts we call unconditioned reflexes. A characteristic of them is a marked stereotypy, some excitation and manifestations of external and internal irritations. However the dog without hemispheres, in spite of the complete preservation of all the apparatuses and functions necessary for the continuation of life and propagation, cannot live by himself—you must help him, otherwise he dies. Nothwithstanding his striving toward food he is unable to find it, he cannot correctly avoid danger, the sexual reflex though retained is insufficient because he cannot locate the opposite sex, etc., etc.

The anatomical substratum of these retained functions is in the nuclei near the cerebral hemispheres, in the basal ganglia. Leaving these anatomical structures after operation, you conserve the unconditioned special reflexes, this basis of the higher forms of activity. However this basis alone without the superstructure is not enough for the preservation of the individual. It is necessary to connect an additional apparatus, the cerebral hemispheres, assuring the animal its orientation in the surrounding world. Only these, the cerebral hemispheres, afford

the animal the possibility of seizing its opportunities—to locate food, to find the other sex, to defend itself adequately, etc.

We can now offer a physiological explanation of the rôle of the cerebral hemispheres, what they add to the basic unconditioned reflexes. We shall concentrate on one reflex, a very important and ordinary one, the food reflex. Comparing two dogs, one having had the cerebral hemispheres extirpated and the other one normal, the first animal, as soon as he has exhausted his food supply, wakes up, wanders about and looks for food but cannot find it; the behaviour of the normal dog is well known to you, he easily finds food and satisfies his hunger. What happens here? Besides the internal stimulations which send the dog without cerebral hemispheres wandering and looking for food, for the normal animal there are special stimulations from the surroundings signalising and directing him toward the food. Here such signals are the appearance and odour of the food. The dog learns at the beginning of his life to locate food by scent and sight, and if the dog during eating never saw nor smelt the food, then it would be impossible for him to find food by its sight and odour. That this is actually true is simply proven. Dr. Tsitovich in the laboratory of Professor Vartanov fed a puppy for seven to eight months on milk alone, never giving him bread. Later the dog ignored bread. As you see it was necessary subsequently to learn to find the bread. What does this mean?

[The following part of this chapter, as it contains material heretofore presented, has been condensed by the translator to include only in abstract the relation of the facts to the theme and the new material.]

A conditioned food reflex may be formed from any stimulus of the external world, to evoke the unconditioned reflex; they are signals with a physiological purpose. The behaviour of the animal shows that the signal "of purpose" becomes so mixed with the goals or purposes themselves that the animal reacts to the signals as if they were the goals, licking for example the electric light signalising food just as if it were the food. All this nervous activity is due to the addition of the cerebral hemispheres. The reflex character of the signals is evident—the external stimulus, a precise point of the nervous system excited leads to the food reaction. You see that the unconditioned reflex, blind, so to speak, becomes seeing thanks to the signalising of the mass of external stimuli formerly having no relation to it. Before us is a nervous synthesis, the connecting function of the cerebral hemispheres, a guide to the work of the whole organism. It is important to note that this multitude of external agents now becoming isolated, now combining, are not constant but temporary excitors of the subcortex, acting only when they correctly signalise. The excitation called the conditioned stimula-

tion undoubtedly proceeds from the cerebral hemispheres because they do not exist in animals after extirpation of the cerebral hemispheres.[1]

What may be said about this fact? As such a temporary union can be formed from each one of the special centres of the underlying subcortex one must recognise as a general principle of the central nervous system that every strongly stimulated centre draws to itself every other weaker excitation existing simultaneously in the system (the law of nervous connexion, association). For elaboration of the union the weak stimulus must precede in time the strong; if an indifferent stimulus is associated *during* eating instead of before it is impossible to form in the dog any but a very unstable and transient conditioned reflex.

The stronger the conditioned stimulus the more energy reaches the cerebral hemispheres and the greater the conditioned reflex. On combining two weak conditioned stimulations we get an exact arithmetical summation; on combining a weak with a strong there is only a slight increase within certain limits; on combining two strong stimulations the effect is less than either component (the law of summation of conditioned stimulations).

Having formed conditioned inhibition by differentiation we can see that such an inhibition is active rather than indifferent, because a positive stimulus used immediately after the inhibitory is without effect, showing the existence of an inhibitory state. This may be constant or, in the case of a delayed reflex, temporary, saving the cortex from useless work. The inhibition may spread (irradiation) or become concentrated, or evoke the opposite process—excitation (reciprocal induction). When the positive or inhibitory stimulus destroys a given equilibrium in the cortex waves with crests of excitation and troughs of inhibition follow—the phenomenon of irradiation with reciprocal induction.

The cells of the cerebral hemispheres, establishing the delicate relation of the organism to its surroundings, being very sensitive, should be protected from excessive strains. Such protection is found in the inhibitory process, which ensues after a prolonged action of the conditioned stimulus without the unconditioned. The correspondence between a strong conditioned stimulus and its effect holds only within limits; too strong a stimulus produces inhibition and the paradoxical phase (where the strong stimuli have less effect than the weak) and an exhausted state of the cortex after work produces the same phase. Inhibition leads to sleep unless there are foci of strong excitation. In the dog we obtained varying degrees of extensiveness and intensity of hypnosis and finally sleep when there was insufficient excitation. Thus inhibition

[1] Although this general statement remains true, recent work (Zeliony, Bard, Culler *et al.*) indicates that some generalised conditioned reflexes may be formed without the cortex.—*Translator.*

has two chief rôles, giving the possibility of a new activity by closing another, adjusting the organism to its surroundings, and secondly leading to sleep.

As a result of irradiation every new conditioned stimulus acts not only according to its strength but according to its setting. Formerly we did not understand the prolonged spread of inhibition over the hemispheres in the dog, but this has been shown from the experiments of Voskresensky on monkeys to be a special property of the dog's nervous system.

The whole cortex is a mosaic made up of excitatory and inhibitory points affecting the activity of the organism; as these points have a reciprocal function the cerebral hemispheres manifest a mobile equilibrium, a kind of stereotypy.

From our thirty years of work we find our dogs fall generally into the four classical types or temperaments of Hippocrates: the extreme excitatory and inhibitory and the two central types of quiet and lively.

These are our chief physiological results, and now I shall take up some questions of pathology. You know that the extreme types, being unable to maintain a balance between excitation and inhibition, more frequently suffer under stress than the central types—a conclusion confirmed by experiments. Thus a dog of the excitatory type is unable to tolerate a succession of positive and negative stimuli without an interval, and becomes more excitable. These animals are more properly hyperasthenics than neurasthenics as we first called them.

The analogy of these states to clinical neurasthenia is a question beyond our competence to decide. We have had in our laboratory several such neurasthenics; we have learned to produce this state in the animal and, more important, to cure him. Bromides given for one or two weeks often restored the ability of the animal to solve his difficult problems.

Passing now to the behaviour of the inhibitory type under similar conditions, the action of a strong excitation or of a "collision" between the excitatory and inhibitory processes, the reverse of what happens in the excitatory type occurs, *viz.*, inability to react to the excitatory stimuli. During the Leningrad flood of 1924 the dogs suffered according to the type to which they belonged. The strong excitatory types were not disturbed, but the inhibitory lost all their conditioned food reflexes, and some suffered to such a degree that we could not cure them. One dog especially remained an invalid, refused food in the presence of any strong stimulation, went into the inhibitory state when many stimuli were given on the same day. Such a condition in which under the influence of strong stimuli the nervous activity shows a predominance of inhibition we call hysteria, in conformity with the term

used in the clinic. An interesting difference is that in clinical hysteria excitation is found mixed with inhibition, but this does not contradict our experimental facts; for in the dog of the inhibitory type after a weakening of the nerve cells, excitation is often marked. One of our dogs belonging to the inhibitory type, which was kept for many hours on the stand as he was used also for experiments on digestion, was exceedingly cowardly while on the stand, but unusually lively when free. Later you shall see facts allowing us to understand this paradox from the physiological point of view.

There is still another important fact for pathology in our material. I have already told you how the cerebral hemispheres manifest a reciprocal action during the period of activity. Although some parts in the hemispheres have been made ill, the whole may yet act normally. Let us say that each one of the elaborated points in the cerebral hemispheres acts upon a separate part of the cortex. Actually we can make any of these parts pathological, without disturbing the other parts of the same analyser, as follows: after elaborating, let us say, a positive conditioned reflex to M100 and a negative one to M95, you reverse them, reinforcing the negative one and not the positive. As a result, the metronome part of the auditory analyser becomes pathological. The law relating size of conditioned reflex to strength of stimulus is destroyed in this part; the weaker metronome gives a greater effect than the strong one. The cells of the given part are now exhausted and do not tolerate the previously strong stimulus. If the injury at this point of the auditory analyser is more extensive the application of the weak stimuli give no effect, or lead to inhibition here, changing the whole behaviour of the animal. The remaining parts of the auditory analyser remain entirely normal, showing no deviation in their reaction to any other auditory stimuli. But if you again apply the pathological metronome the paradoxical or equivocal phase sets in, inhibition follows, the reaction to all our conditioned stimuli is lost; such a state may last for several days.

Now we shall take up *hypnosis* in our animals, which has explained the symptoms of some mental diseases. As we have seen, sleep and the waking state are periodic phases of two extreme states of the nervous system. Inhibition, having arisen in a certain part of the cortex, gradually settles over all the cerebral hemispheres, leading to inactivity of some parts and activity of others, varying in the localisation as well as the intensity of inhibition. For example, the food reflex of the dog appears in two forms, the secretory and the motor. An interesting dissociation is seen in the work of the cerebral hemispheres—saliva flows, but the dog does not take the food; a strange picture, the animal correctly differentiates signals, but cannot eat until the hypnotic state is

dissipated. The explanation is that the voluntary movement arises in the motor area of the cortex, and while other cortical parts are active such as that leading to the secretion of saliva, the motor part is inhibited.

This is an example of dissociation of the cerebral activity; the motor area is inhibited, but other areas are active. The motor part is not inhibited immediately; when you feed the dog a series of activities occur, such as have been described in a previous chapter. Inhibition as well as excitation follows a definite course; in the very beginning of hypnosis the dog first loses the use of the tongue and masticating muscles but not those of the trunk, so that on giving the conditioned stimulus, saliva flows, the dog turns toward the food, inclines his head, but cannot take it, the tongue protrudes as in paralysis but the mouth is closed. This coincides with some of our other facts—that inhibition or the pathological process first attacks those parts which have done the most work.

The cataleptic phase may ensue—the dog cannot turn the body, remains like a marble statue. Inhibition has spread to the subcortical centres, however not to those of equilibrium in space. Later complete sleep may follow. Thus inhibition differs in both intensity and localisation; dissociation of activity may exist not only in the cerebral hemispheres but in several subcortical centres. It is easy to imagine what a great variety of dissociation occurs in the human being, separated from all other animals by the size of the cerebral hemispheres and the complexity of their activity. However the basic principles underlying the higher nervous activity is the same for both the human being and the higher animals. Thanks to Professor Ostankov I have been able to see facts in the clinic, in dementia praecox, which confirm my own experimental observations—similarities to our hypnotic states. In order to explain this I shall now discuss the reciprocal relations of the cortex and the subcortex.

The higher nervous activity represents the activity of the cerebral hemispheres and the underlying subcortical ganglia, the united action of these two most important parts of the central nervous system. The subcortical ganglia, as I have said, are centres of the most important unconditioned reflexes or instincts—the food, the defence, the sexual, etc., representing the great strivings, the chief tendencis of the animal organism. In the subcortical centres are located a mass of the most fundamental external living activities. From the physiological point of view the subcortical centres are characterised by inertness as regards both excitation and inhibition. A dog without cerebral hemispheres does not react to the mass of stimuli falling on him from the external world, the external world for him is, so to speak, contracted. Such a dog is not able to extinguish reflexes, for example, inhibition of the

orienting reflex takes place only after many repetitions, while in the normal animal extinction occurs after 3-5 repetitions. The rôle of the cerebral hemispheres in relation to the subcortex concerns the more delicate and far reaching analysis and synthesis of all the external and internal stimuli, for it and, so to speak, for the correction of the inertia of the subcortical ganglia. On the ground of the general crude functioning of the subcortical centres, the cortex embroiders a pattern of more delicate movements in closer correspondence to the living conditions. On the other hand, the subcortex has a positive influence on the cortex.

Here are facts which illustrate this. A hungry animal not fed for days gives much larger conditional reflexes than one just fed. The recent work of V. V. Rikman in this laboratory furnishes us with important details. I have already told you of the relation between the size of the reflex and the strength of the stimulus under normal conditions. But if you increase the food excitability of the animal by limiting his rations, this law does not hold; the strong and the weak stimuli are equal in their effect or more often the weak gives a greater effect (the equivocal and paradoxical phase). Conversely, when you feed the dog before the experiment, you again get the strong and weak stimuli producing equal effects. But there is a great difference between the two cases: in the first the level of equivalence is higher, in the second instance, low. In the latter case it may go so far that the dog does not eat with the strong stimuli but only with the weak. In both cases it is the strong stimuli that are affected; in the hungry and in the satiated dog the strong conditioned reflexes are smaller than normal. With an increased alimentary excitability the tonus of the subcortex powerfully changes the cortex, increasing the labileness of the cells, and the strong stimuli become transmarginal, maximal, resulting in inhibition. On the contrary, with a lowered alimentary excitability the impulses from the subcortex decrease, the labileness of the cortical cells diminishes, especially those which were most exercised, naturally those cells receiving the strong stimulations.

Such an influence of the subcortex on the cortex is clearly seen on application of some weak stimuli, according to the definite law: the effect of weak stimuli is parallel to the rise and fall of the alimentary excitability.

The influence of the subcortex on the cortex is seen in other of our experiments. In dogs with exhausted cerebral cells in whom the reflexes had become weak or had disappeared, the seminal ducts were tied and glands transplanted from other dogs, presumably increasing the amount of sexual hormones in the blood (rejuvenation operation). The operation was beneficial, all the reflexes returned, the nerve cells were capable

of solving the difficult task. This influence was brief, after two to three months the animal lapsed into his former state (experiments of D. I. Soloveychik). Reversing the experiment (removing the sexual glands in a dog with a normal higher nervous activity) there was a notable impairment of the function of the cerebral hemispheres, resulting in a condition similar to hysteria or reminding us of the first stage of dementia praecox.

One may conclude that the subcortex is the source of energy for the whole higher nervous activity, and that the cortex plays the rôle of regulator for this blind strength, delicately guiding and controlling it. The inhibitory influence of the cortex, established by the Russian physiologist Sechenov, appeared prominently in one of our experiments, having, it seems to me, clinical importance. A collaborator of mine was shown a case of war neurosis in a former commander, who on falling to sleep began to cry, wave his hands and legs, to give orders, in a word to re-enact the war scenes. There were no other symptoms of abnormality. The case is similar to what happens in the dog. In the experiments of G. P. Konradi several conditioned reflexes were elaborated to different tones from the same instrument, connected with different unconditioned reflexes. One tone was combined with acid, another with food, the third with an electric shock to the paw. The shock was of such strength that the dog gave a marked defence reaction, tore the stand, yelped, and once fell off the table. The extreme intensity of the defence reflex was shown by the fact that the acid and the food reflexes also were transformed into the defence. The acid and the defence reflexes were discontinued, and only the food reflex was used (by Rikman). The transfer of the food reflex to the defence gradually disappeared toward the end of the second month. But some time later, it was seen that the dog fell into the hypnotic state, the equivocal or paradoxical phase ensued, and after feeding the defence reflex returned. You see a complete analogy with the clinical case; in both a strong past experience, in both the traces of these strong experiences are manifested during hypnosis. Obviously the explanation lies in the fact that the subcortical centres retain traces of the past severe stimulus and these traces result in disorganisation as soon as the weakened inhibitory action of the cortex on the subcortex sets in, or even when positive induction proceeds from the cortex to the subcortex.

Now that we have become acquainted with the characteristics of the cortical activity in its reciprocity with the subcortical centres, you will understand how schizophrenia is in a certain phase a manifestation of inhibition in the cerebral hemispheres. My attention in the clinic was drawn to those symptoms, unfortunately without a special name: that the patient does not converse with you and answer questions, but

sometimes when these are put very calmly in quiet surroundings you may receive a reply. Undoubtedly this symptom is analogous to the paradoxical phase of the hypnotic state, when the animal reacts to weak but not to strong stimuli. Such symptoms as echolalia, echopraxia and stereotypy are readily explained from our point of view as varying degrees of hypnosis, concentrating now in one part, now in another. For a number of reasons we are justified in considering some symptoms of schizophrenia as an inhibitory state of the cortex, protecting the cells from further exhaustion. The playfulness seen in hebephrenia, a symptom unnatural for the patient, is also comprehensible as a freeing of the underlying subcortical centres from the inhibitory action of the cortex.

I have directed your attention to the varied hypnotic phenomena in our animals, to the dissociation in the activity of the cerebral hemispheres, when some points of the cortex are inhibited and others excited. It is easy to see how great this variation and dissociation must be in the human being. Many powerful intellects will be required to solve these problems completely, and it gratifies us not only that we have added facts obtained from the experimental animal, but that these facts combining with other facts as a schema open a direct road to the successful investigation and complete understanding of the work of the cerebral hemispheres in man.

In conclusion, a few words about the relation of current physiology of the brain (as I have expounded it to you) and contemporary psychology. That our study of the higher nervous activity is on the right path is confirmed I think by the disputations among the psychologists. This year in America at the Psychological Congress I spoke with the representatives of the various psychological schools. Present-day psychology is sharply divided into two groups—the old association psychologists oppose the Gestalt-psychologists. According to the former, the function of the cerebral hemispheres consists in unifying the elements earlier separated, hence their main problem is the analysis of the connexions; according to the latter group, the higher nervous activity does not admit of factoring, always appearing as a whole, and their discussion is the description and explanation of such structures of animal and human behaviour. Physiology of the cerebral hemispheres in its present development, based on a strict factual material, can unite both these views. To us it is clear that the cerebral hemispheres represent a functional mosaic of separate parts, each point having a definite physiological action, positive or inhibitory. These elements are joined at any given moment in this system where all of the elements are in a reciprocal relation with each other. These are the simplest facts of our experiments. You form a number of conditioned reflexes from differ-

ınt conditioned stimuli applying them in fixed order separated by equal ntervals, and you obtain a definite effect. The order or the interval nay produce other effects. To what extent the elaborated system plays ı rôle in the work of the cerebral hemispheres is seen in our dogs by he case in which an alteration of the system abolishes the conditioned eflexes. Thus from the standpoint of the physiologist the cortex of the erebral hemispheres simultaneously and constantly does both analysing ınd synthesising work, and any dividing of these functions or giving preference to the study of one of them instead of both will not succeed n representing the activity of the cerebral hemispheres. Just as analy-sis and synthesis in the hands of the chemist is a powerful agent for he study of the structure and explanation of the properties of the ınknown chemical compound, so for physiology the analysis and syn-hesis of the nervous processes blazes a straight path to the comprehen-sion of the intricate functional structure of the cerebral hemispheres.

CHAPTER XLV

CONCERNING THE POSSIBILITY OF FUSION OF THE SUBJECTIVE WITH THE OBJECTIVE

THE physiology of the higher nervous activity arose under our eyes when the physiologist systematically began to investigate by the objective conditioned reflex method the normal activity of the cerebral cortex and the neighbouring subcortex—the special apparatus of connexion of the whole organism with the surroundings—establishing the basic laws of this activity, *i.e.*, when he began to think as he did in the investigation of the digestive and circulatory glands.[1]

Dating from this time it became gradually possible to relate the phenomena of our subjective world to physiological nervous relations, to blend, as it were, one with the other. One could not dare do this when the physiologist had only the experiments with the artificial stimulation of various points of the cortex or with removal of different parts of the brain.[2] Then how strange that two fields of human knowledge, dealing actually with one and the same organ in the animal and in man (who can now dispute this?) struggled more or less separately and sometimes even directly opposed one to the other. As a result of this anomalous state of affairs the physiology of the higher parts of the brain remained stationary for a long time, and psychology could not even elaborate any general language for its phenomena in spite of the reiterated attempts to introduce system into the many psychological words.[3] Now the situation is completely changed, especially for the physiologists. Before us is opened an unbounded horizon as observed from the experiment, experiments without limit. The psychologists have obtained finally a stable position, a natural system of the basic phenomena they study in which it is easier for them to dispose the endless chaos of human experiments. Marching forward and press-

[1] Pavlov has said: "The study of conditioned reflexes is the real, true physiology of the cerebral hemispheres, as the study of the circulation of the blood is the physiology of the heart and blood vessels, and the study of digestion (mechanical and chemical refinement of food in the organism) is the physiology of the digestive tract, etc." (Inscription on a photograph of Pavlov dedicated to the Pavlovian Laboratory of the Phipps Psychiatric Clinic.)—*Translator.*

[2] This statement is interesting, expressing the historical attempt of Pavlov to substitute by the conditioned reflex method a more nearly normal animal for the pathological part animal of the acute experiment in the study of human behaviour just as he had done with his chronic fistulae in the study of digestion.—*Translator.*

[3] The state of psychology subsequent to the physiological work of Fritz and Hitzig in 1870.—*Translator.*

ing onward, the natural and unavoidable approach and final fusion of psychology with physiology, the subjective with the objective is achieved —the actual question so long disquieting to human thought.[4] And every further means to this union is a fundamental problem of the future of science.

The most common example of this blending obviously exists in mental diseases, where the deterioration of the subjective world of the human is evidently bound up with the anatomical and physiological destruction of the superior parts of the brain.

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[4] Pavlov describes here the present condition where physiology and psychology so blend that it is frequently a matter of personal preference or prejudice whether an investigator calls himself physiologist or psychologist.—*Translator.*

CHAPTER XLVI

EXPERIMENTAL NEUROSES

(Read in German at the First International Neurological Congress, Berne, September 3, 1931.)

NEUROSES IN DIFFERENT TYPES—EFFECT OF CASTRATION—ANALOGY WITH HUMAN NEUROSES.

As NEUROSIS we understand a chronic deviation of the higher nervous activity, lasting weeks, months, and even years. For us the higher nervous activity is manifested chiefly in the system of conditioned positive and negative reflexes to any stimulus and partially, but to a lesser degree, in the general behaviour of our animals (dogs). The factors which have produced neuroses in our animals are: first, stimuli too strong or too complex; secondly, a strain of the inhibitory process; thirdly, collision (direct consequential) of the two opposing nervous processes; fourthly and finally, castration.

Neuroses are expressed in a weakening of both processes separately or together, in chaotic nervous activity, and in various phases of the hypnotic state. Different combinations of these symptoms give entirely distinct pictures. Whether or not the animal breaks down and in what form depends upon the type of nervous system.

On the basis of our investigations we found three main types. The central type is the ideal normal type in which both opposing nervous processes exist in equilibrium. This type is represented in two variations: the calm stable animal, and on the contrary the very lively ones. There are two other extreme types: one strong, even too strong but not completely normal, because the inhibitory process is comparatively weak; and the other, a weak type in which both processes are weak but especially the inhibitory one. Our classification of types more nearly coincides, it seems to me, with the classical Hippocratic grouping of temperaments.

For the sake of brevity I shall mention only a few examples of our latest experiments on castrated animals. In animals of the central type the evident disorder continues generally only some months after castration; later the animal behaves normally. Only under increased excitability was it possible to be convinced that the functional ability of the cortical cells had suffered. The excitability in the case of the food conditioned reflexes is easily changed by different degrees of hunger.

In some individuals of the strong type the evident pathological state after castration continues for many months, for years and longer, and

CHAPTER XLVII

CONTRIBUTIONS TO THE PHYSIOLOGY OF THE HYPNOTIC STATE IN THE DOG

(From *Reports of the Physiological Laboratory of Pavlov,* Vol. IV, 1932, with M. K. Petrova.)

DESCRIPTION OF HYPNOSIS—RELATION OF MOTOR AND SECRETORY REACTIONS—ANALOGY TO HUMAN HYPNOSIS—NEGATIVISM—THEORETICAL EXPLANATIONS.

Besides the conventional historical method of hypnotising dogs (turning them on the back and holding them in this unnatural position), in our laboratory, in the study of the normal activity of the higher parts of the brain, hypnosis leading to catalepsy has made it possible for us to investigate in more detail the varied and delicate manifestations of the hypnotic state. This hypnosis can be produced by the continuation of one and the same stimulus, finally resulting in an inhibitory state of the corresponding cortical cells, representing on the one hand various degrees of tension and on the other hand a varying extent of spread over the cerebral hemispheres and farther down into the brain, as described in a previous chapter.

Additional observations have revealed many more symptoms of the hypnotic state, finer gradations often hardly differing from the waking state, a great mobility of the hypnotic state in dependence upon delicate changes of the milieu.

In the present article we shall describe these phenomena observed in two dogs (used by one of us—M. K. P.—in the study of various conditioned reflexes) which now constantly fall into the hypnotic state as soon as they come into the customary experimental setting.

For a long time we have frequently noted in our laboratory when using the conditioned food reflex, the salivary secretion and food motor reaction, that the dog becomes drowsy. The result is that either with our artificial conditioned stimuli, or more often with the natural stimuli, such as the odour of the food (which we have shown also to be conditioned) saliva begins to flow freely but the animal does not eat. During this state we have observed remarkable and interesting variations of the motor food reaction—evidently different degrees of intensity of hypnosis seen now in one dog, now in another. In one animal under light hypnosis there appears what in psychiatry is called *negativism.* After the conditioned stimulus has been continued for some time we give the dog food and he turns away from it; we remove the food, and he strains toward it. We again offer food and he turns away, we remove it

and he tries to get it. The reaction of avoiding the food we call the negative or first phase of negativism, the movement toward the food, the positive or second phase. Such negativism may be repeated many times; most dogs do not take the food. The degree of hypnotisation is measured by the number of times such a procedure can be repeated. As hypnosis is beginning, the food is taken and devoured the second time it is offered; when hypnosis becomes deeper, both phases of negativism can be repeated many times; in the further grades of hypnosis the dog does not take the food no matter how many times we offer it. But if by one or another means we dissipate the hypnosis—by removing the salivary cup attached to the dog, undoing the leash which ties the dog above to the stand, or by any other means—the dog greedily begins to devour the same food.

The motor reaction to food in another dog appears still more complicated. . . . During the action of our conditioned stimuli (usually at the end of their isolated action) the dog, if sitting, stands; if standing, turns the whole body to that side whence the food is given; but when the food is presented he moves his head away either to the side or above, showing the first phase of negativism. Now if the food vessel is taken away the animal moves his head toward it, follows the food vessel, showing the second phase. After several such repetitions the dog finally holds the jaws over the food but does not take it, cannot take it. As if with great difficulty, he begins little by little to open and close the mouth but nevertheless not taking the food (abortive movement). Then he begins to move the jaws freely. Now he takes the food in small portions, and finally grabs it with wide open mouth rapidly and repeatedly. Thus in this phase of hypnosis we can see three different states in three parts of the skeletal musculature concerned with eating: strong inhibition, rigidity of the muscles concerned with eating (grasping muscles and tongue); considerable immobility, but in the form of periodic activity; negativism of the neck muscles, however with normal functioning of the trunk muscles. The deeper the hypnosis, the more rigid, the more inhibited the neighbouring musculature: the tongue protrudes from the mouth as if paralysed and the jaws are completely immobile. In the neck muscles negativism occurs only in the first negative phase. Later the movements of the head are entirely absent, the dog can turn only the trunk during the conditioned stimulus. Finally, in deeper hypnosis even these motions to the conditioned stimulus and to the food fail. All these manifestations can be immediately removed by the means used with the first dog.

Concerning the food motor reactions it is necessary to add the following: the slightest change in the accustomed form of the food or

even in the method of giving it results in the negative motor reaction becoming positive, *i.e.*, the dog takes the food just refused. We give the dog food in the usual vessel containing some moistened cheese and meat powder. He does not take the food. But if the food in the same vessel is heaped in separate lumps, the dog gulps it greedily and later begins to eat all that remains. Also the positive reaction may be obtained simply by giving the food on a plate or on paper. The dog takes the food from the hand instead of from the vessel, and sometimes after our conditioned stimulus, having refused the food in the vessel he begins to lick the same meat powder when it has spilled on the table.

Besides the above motor phenomena there occur in hypnosis other motor reactions which merit our attention. Many dogs in the alert state, after they have eaten a portion of the experimental food, lick the front paw and the front part of the chest. In hypnosis this licking is very prolonged, taking a special form in one animal. Having licked and moistened the paw, especially the pads of the front paw, he rubs it over the salivary cup fastened over the fistula, doing this many times, unless disturbed. The dog never does this in the waking state, although some dogs do scratch at the salivary cup when it is first applied, later ignoring it completely. In our hypnotised dog one may reasonably conjecture that this is a manifestation of a special defence reflex. When a dog has a skin abrasion he usually cleanses it with saliva, licks the wound (therapeutic reflex). In the above dog evidently the irritation of the wax holding the salivary cup evokes this reflex; being unable to reach the place with the tongue he uses the paw. Many of the described variations of the motor reflex to food are generally seen in the same experiment, one following the other quickly. This mobility of the hypnotic state manifests itself in other phenomena than in the above, which we have previously described.

Hypnotisation begins when the dog enters the experimental room, sometimes even before he gets on the stand, increasing as the experiment progresses.

The secretory and motor food reflex seem frequently to be antagonistic. If during stimulation there is secretion without the motor reaction the dog does not take food, but if on the contrary the dog eats greedily then the conditioned secretion does not appear.

Experiments illustrating these points follow.

April 17, 1930 Dog "Beka"

Conditioned Stimulus	*Conditioned Secretion in Drops for 30 Seconds*	*Motor Food Reflex*
Rattle	15	Negativism, then eating
Bell	15	Abortive movement, does not eat for a long time

April 18, 1930

Rattle	1	Food taken immediately, and eaten sluggishly
Bell	0	Food taken immediately, and eaten greedily

Sometimes these apparently antagonistic relations between the secretion and the motor reactions quickly change during an experiment.

April 12, 1930 Dog "John"

Rattle	5	Negativism
Bell	0	Takes food immediately

We have described before how during hypnosis a well elaborated inhibitory stimulus can fluctuate, now becoming weaker, now stronger. Also an exceedingly strong conditioned stimulus weakens or disappears while those of average strength remain unchanged or grow stronger. . . . Thus:

Conditioned Stimulus	*Conditioned Secretion in Drops for 30 Seconds*	*Motor Food Reflex*
Rattle (moderately strong)	0	Does not eat for a long time
Bubbling (moderately strong)	0	Ditto
Noise (very strong)	5	Short negativism
Bell (moderately strong)	0	Does not eat for a long time

Attempting to explain the mechanism of the above facts, we recognise that the described nervous activity has to do not only with the cerebral hemispheres but with the lower parts of the brain and even with the spinal cord. According to the phylogenetic development of the central nervous system the nervous connecting system in the form of the reflex centres approaches closer and closer to the head end, representing a better analysis and synthesis of the stimulating agents in connexion with the extending complexity of the organism and its increasing relations to the surroundings. Thus gradually with the more or less stereotyped nervous activity with the preformed complex physiological functions, evoked by elementary and few stimuli, the higher nervous activity is developed, including all the preformed complex stimuli. Then there arises for the investigator a very intricate problem of connexion—the form of unions of these various stages.

Returning to our first question about the separation of the secretory and the motor reaction of our conditioned food reflex it is necessary to determine what in this reflex can be accounted for by the cortex and what by the subcortex, or, in the usual vernacular, what in this process is voluntary and what reflex. Are the secretory and the motor com-

ponents of the conditioned food reflex dependent in the same way upon the cortex; does not the motor relate to the cortex and the secretory to the subcortex?

Let us return to the facts. In human hypnosis we recognise that there are in the cortex, together with the magnificent representation of the external world through the afferent fibres (a necessary condition of the higher regulating function), an extensive representation of the inner world of the organism, uniting the work of the many organs and tissues, the innumerable organic processes. Especially convincing here are the actual details duplicated in hysterical pregnancy. There arise many processes relating to the activity of such passive tissues as the adipose tissues and these processes are reinforced by the cerebral hemispheres. These two projections are very different. While the projection of the skeletal muscular apparatus can be finely adjusted to the representative of the external energies, such as the auditory and visual, the projection of the other internal processes remains sharply separated. Perhaps this depends upon the slight practical use made of this agency. In every case it is a constant physiological fact. On this basis the voluntary and involuntary functions of the organism are separated, the activity of the skeletal musculature being counted as voluntary. Voluntary means that the work of the skeletal musculature on the first plan is determined by its cortical projection, the motor area of the cortex (the motor analyser in our terminology), directly connected with all the external analysers, constantly directed to the analytical and synthetical work of these analysers.

Proceeding from these facts the mechanism of elaboration of our conditioned food reflex may be thought of as follows: On the one hand it is a union of the cortical parts of the application of the conditioned stimulation with the reflex food centers of the subcortex with all its particular functions; on the other hand it is a union of the same parts with the corresponding parts of the motor analyser participating in the act of eating. Thus we can understand during hypnosis a disunion of the secretory food component from the motor. On account of the state of hypnosis the motor analyser is inhibited but all the remaining part of the cortex is free, spreading to the food center of the subcortex with all its functions. But the inhibition of the motor analyser excludes from this reflex the motor component, producing conditioned inactivity in the last stage of movement, in the cells of the anterior horns; thus from the food act is left visible only the secretory reaction.

Now the opposite case: to the artificial conditioned stimulus saliva does not flow, but the motor reaction is present, the dog immediately eats the food. The explanation is simple: a general slight restraint by the whole cortex means that one artificial stimulation is not sufficient

for the overcoming of the corresponding inhibition, and only during the giving of food, when the artificial conditioned stimuli are summated with the natural ones (sight and odour of food), does there appear the total reflex with both components.

Another case met with in other experiments than those involved in hypnotism can be profitably analysed here. The dog eats the food but the saliva does not flow for ten or twenty seconds. This is undoubtedly connected with the development of special inhibition in the cortex by the artificial conditioned stimuli for a definite period of time. How is this to be understood? What is its mechanism? From the points of the artificial conditioned stimulations one may think there proceeds a strong inhibition to the entire subcortical food centre including its two chief components, the secretory and the motor, the inhibition also spreading to the corresponding cortical motor analyser. When the food is offered, the parts of the stronger natural conditioned stimulation, which had not participated in the development of inhibition, quickly bring about an excitation of the food parts of the motor analyser, this analyser being more labile than the subcortical centre. In this latter centre inhibition is dissipated only after a longer action of the unconditioned stimulus. Perhaps this is partly analogous to the forced introduction of food into the mouth, its mastication and deglutition, when there is absolutely no appetite.

The following hypnotic phenomenon, the physiological mechanism of which concerns us at present, is negativism. It is of course a manifestation of inhibition because it represents a phase which by degrees passes into sleep. There is not a doubt that this is a cortical localised inhibition, because the corresponding salivary reaction has been shown to be conditioned, *i.e.,* a cortical activity. Then it is natural to conclude that this is a motor inhibition relating to the motor area of the cortex, to the motor analyser. But how is the form of this inhibition to be understood? Why at first does it correspond to the negative phase of the motor act and later to the positive? What kind of change is this? It seems to us that this can be easily related to a fact previously known to us. When hypnosis begins, *i.e.,* inhibition, the cortical cells pass over into a weaker, less efficient state. This is the so-called paradoxical phase. Then the usually strong stimuli evoke not excitation but inhibition. We may think that proceeding from the motor analyser the movements consist of two opposed innervations—the positive and negative, movement toward the object and away from the object, similar to the relations of the flexors and extensors of the extremities.

Negativism can now be understood in the following way: the conditioned stimulation from the area of the cortex is more or less uninhibited, producing excitation in the correspondingly positively innervated part

:he motor area, which on account of its hypnotised state is in the adoxical phase. Therefore the stimulation does not lead to excita- ı of this part but to a deeper .inhibition. Then this unusual and .lised inhibition evokes, by the law of reciprocal induction, excita- ı of the negative phase of negativism. On removal of the stimulus unusually inhibited positive part passes, by virtue of internal procal induction, into the excitatory state, and the induced excitation :he negative part becomes inhibitory and of itself positively induces positive part. Thus the positive part after the first of its unusual ibitions becomes doubly excited. Consequently, if the hypnotisation s not go further after giving and removing the food one or several es, the positive phase predominates and the dog begins to eat. We e before us a very labile state of the cellular activity. That this is is proved by the further course of events. If the hypnotic state 'einforced there remains only a single negative phase, the reverse action is impossible and further there is absent any excitation of the or apparatus.

n this stage of hypnosis in the conditioned food motor reaction can seen one of the factors in the fractional distribution of inhibition r the cortex. In one of our dogs as mentioned in the factual part of article, there appeared the well known consequential inhibition in neighbouring parts of the subcortex. This may be explained by the ; that inhibition set in before hypnosis was complete. During the eated act of eating the maxillary muscles and tongue were most rcised, then the neck muscles and lastly the trunk, and inhibition fol- s in that same sequence.

'he interesting fact of an excitatory act brought about by changing method of feeding during the inhibition of hypnosis has its basis in a property of the cortex. Many years previously Volborth in our oratory showed that there is conditioned inhibition of the second er just as there is a conditioned stimulation of the second order. If elaboration of an inhibitory process coincides with an indifferent nulus the latter quickly becomes an inhibitory agent. Thus it is easy understand why everything falling upon the cerebral hemispheres ing hypnosis (a certain grade of inhibition) also becomes inhibitory. s is why simply bringing the dog into the experimental room is often icient to produce hypnosis. And every new stimulation however ht, although not at once dissipating the inhibition, later produces a itive excitation of the cortex.

'he therapeutic reflex referred to in this article is only one of the sub- :ical reflexes arising during hypnosis after a short process of feed- . The act of eating with its stimulating components, a strong nulation for the more or less hypnotised cortex, deepens the cortical

inhibition. From the cortex there follows a positive induction to the subcortical centers, so that at the given moment there is a subminimal extra stimulation, or the traces of past strong stimulation. The animal begins to sneeze, scratch, etc., which he never does when awake. Here is an experimental case analogous to a war neurosis as described in another lecture of this book.

Concerning the conditioned inhibitory stimulation and its influence on the overflowing inhibition we have known for a long time that it has a double, reversed action. If there is a weak tension of the hypnotic state the well elaborated inhibitory stimulation, which concentrates to some extent the overflowing inhibition, either entirely dispels the hypnosis or lightens it. Conversely a strong inhibitory tonus of the cortex deepens the inhibition, in summating with the extra inhibition. Consequently the result is determined by the relations of the forces.

Finally in the last experiment of the factual part of this article: the very strong stimulation, in contrast to the moderately strong and weak stimuli, often evoked not inhibition but a positive action. This can be accounted for by direct action of exceedingly strong stimuli on the subcortex, the existing strong excitation of the subcortex being passed on to the cortex, dissipating or weakening its inhibitory process. Such an explanation serves us well in our experiments: when a constant experimental setting begins to hypnotise some of our animals we oppose this by increasing the food excitability through giving the dog less in his daily ration. The increased food excitability is probably located in the subcortical food center.

CHAPTER XLVIII

CONCERNING HUMAN AND ANIMAL NEUROSES

(Reply to Schilder's Criticism—Neuroses and the Physiological Analyses.)

DISCUSSION OF ANALOGIES IN AN EXPERIMENTAL CASE.

IN THE *Journal of Nervous and Mental Diseases,* volume 70, there is printed an article by Dr. P. Schilder, entitled "The Somatic Basis of the Neurosis," in which the author recognises that what we, I and my collaborators, call neuroses in our experimental animals (dogs) "are formed of the manifestations of neuroses." Such recognition from a competent source is, of course, very valuable for us. But I most emphatically object to what the author further says concerning the comparative study of these neuroses in man and in animals. He says, "The important experiments of Pavlov and his pupils on neuroses can be understood only if we look upon them in the light of our experiences in the neuroses. We cannot interpret the neurosis by means of the conditioned reflex, but by means of the psychic mechanism we have studied in the neurosis we can well explain what occurs in the conditioned reflex."

What is the meaning of the term "interpretation" or "understanding" of the phenomenon? The reduction of the more complex to the more elemental is a simple thing. Consequently the human neuroses should be explained, understood, *i.e.,* analysed, by the help of the animal neuroses, as naturally the more simple, and not by the reverse procedure.

In man it is necessary first to determine exactly wherein lies the deviation from the normal. But the behaviour of the normal is exceedingly varied in different persons. Then one should consider together with the patient, or independently of him, or even against his resistance, among the chaos of affairs vital to him, those conditions that have acted immediately or gradually, and with which perhaps the origin of the illness may be justifiably linked. Further, one must know why these conditions and difficulties produced such a result in our patient, when they are without influence on other people. And why does this lead to a certain complex in one patient and to an entirely different one in another patient. I am taking only the most important group of questions, omitting the details. Are there always entirely satisfactory answers to all these questions?

But this is only a part of the matter if one attempts a complete and final analysis. Of course the deviation in behaviour of our patient comes from a change in his nervous system. Who can now deny that? Therefore it is necessary to answer this question: how and why do there arise in the given case changes in the normal processes of the nervous system? Are not these real prerequisites? And where are they all satisfied? With what does one deal in the dog?

First of all, one sees that neuroses are possible to obtain and without difficulty, if only one has an animal in whose makeup there is not a proper balance between its fundamental reactions of nervous activity—as yet not further analysed physiologically—that is, between the excitatory and inhibitory processes.

Further, with such an experimental animal it is definitely known that this insufficient balance, peculiar to the make-up of the particular animal, finally breaks down under certain fundamental conditions. This happens mainly under three conditions, three circumstances. Either extremely strong stimuli in the nature of conditioned stimuli are used in the place of those that are only weak or moderately strong and which ordinarily determine the animal's activity; *i.e.*, its excitatory processes are overstrained. Or the animal is required to exert a very strong or a very protracted inhibition; *i.e.*, its inhibitory processes are overstrained. Or, finally, a conflict between both these processes is produced; *i.e.*, conditioned positive and negative stimuli are applied one right after the other. In all these cases with the proper animal there develops a chronic disturbance of the higher nervous activity, *a neurosis*. The excitatory type loses almost completely its ability for any inhibition and generally becomes unusually excited; the inhibitory type, though hungry, refuses even to eat under the influence of the conditioned stimuli and generally becomes exceedingly ill at ease and also passive with the least change of its surrounding environment.

One can conceive in all likelihood that, if these dogs which have become ill could look back and tell what they had experienced on that occasion, they would not add a single thing to that which one would conjecture about their condition. All would declare that on every one of the occasions mentioned they were put through a difficult test, a hard situation. Some would report that they felt frequently unable to refrain from doing that which was forbidden and then they felt punished for doing it in one way or another, while others would say that they were totally, or just passively, unable to do what they usually had to do.

And so, what my associates and I have found with our animals are elemental physiologic phenomena—the frontier of physiologic analysis (in the present state of knowledge). At the same time it is the prime

and most fundamental basis of human neurosis and serves as its true interpretation and understanding.

Hence in the case of man, under the complications of his existence and with his many different reactions to it, when it comes to analysis and to the ultimate aim of curing him, one always has to face the very difficult question: What circumstances in his life are excessively strong for the nervous system in question, where and when has he encountered a conflict intolerable for him, requirements that he become active and requirements that he hold himself back?

How in the opinion of Dr. Schilder could the innumerable subjective experiences of the neurotic patient under the extreme complexity of human higher nervous activity, as compared with dogs, give anything useful in the way of an explanation of the elementary neuroses of animals, when those experiences are only different variations of one and the same physiologic process, so clearly seen in dogs?

Of course, for the final physiologic analysis of the problem of neuroses and psychoses there remain a number of unsolved questions. Is it possible to produce neuroses in cases of well balanced nervous systems? Is the initial unbalance of the nervous system a primary phenomenon: *i.e.*, an innate property of the nervous tissue itself, or a secondary one depending on some innate peculiarity of other systems of the organism apart from the nervous system? Do there not exist along with the innate properties of the nervous system also other conditions in the organism which determine this or that degree of normal function of that system?

I am busy at the present time with some of these questions and already have material for their decision.

It stands to reason that, apart from these special questions which concern the general problem of disorders of normal nervous activity, there remains before the physiologist the question relating to the physicochemical mechanism of these very elemental nervous processes: of excitation and inhibition, of their reciprocal relations and tensions, and of excessive strains on them.

CHAPTER XLIX

PHYSIOLOGY OF THE HIGHER NERVOUS ACTIVITY

(Read before the XIV International Physiological Congress, Rome, September 2, 1932.)

BEGINNING OF PAVLOV'S STUDY OF FUNCTIONAL CEREBRAL PHYSIOLOGY—CONFLICT BETWEEN EXCITATION AND INHIBITION—DIFFERENT FORMS OF INHIBITION—TRANSMARGINAL INHIBITION—SLEEP CENTER—FOUR LAWS OF NERVOUS ACTION—CORTEX AS MOSAIC—DYNAMIC STEREOTYPY—TREATMENT OF NEUROSES WITH BROMIDES—FUNCTION OF FRONTAL LOBES.

Now I suppose that for the last time I stand before a general meeting of my colleagues, and therefore I permit myself to draw your attention to a more or less systematised epitome of my and my collaborators' recent investigations, consisting of the entire half of my physiological activity. Much of this has already been published.

I offered this summary with a fervent dream of the great horizon ever widening before our science, and of its growing influence on the nature and fate of the human being.

For anatomy and histology the cerebral hemispheres were always just as capable of study as any other organ or tissue, *i.e.*, they were investigated by the same methods, adapted, of course, to their special properties and structure. Their physiology occupied an entirely different position. In every organ of the body, once its general rôle in the organism was known, the conditions and mechanism of its function become a subject of investigation. The rôle of the cerebral hemispheres is relatively well known—the rôle of an organ dealing with the most intricate connexions of the whole organism to the surroundings—but physiology had nothing further to do with their functioning. For physiology the study of the cerebral hemispheres does not begin with the concrete reproduction of this function, behind which follows step by step the analysis of the conditions and mechanism of the function. The physiologist has many facts concerning the hemispheres, but the facts do not stand in clear or close relation to their daily normal work.

Now after thirty years of intense and uninterrupted work with my numerous collaborators, I am bold enough to say that the state of affairs has radically changed, that at present, remaining a physiologist, *i.e.*, making the same objective observation as are made in the rest of physiology, we are studying the normal work of the cerebral hemispheres. Also we constantly and more and more introduce analysis, recognised as a criterion of every true scientific activity; an exact prescience and

control over the phenomena testifies to the indisputable seriousness of such a study. This investigation irresistibly advances, without the slightest hindrance, before us there extends a longer and longer series of relations constituting the most intricate external activity of the higher animal organisms.

The central physiological phenomenon in the normal work of the cerebral hemispheres is what we have called the conditioned reflex.[1]

Now arises the question: with what internal processes and by what laws is the work of the hemispheres completed, what are the general and special properties compared with the segmental nervous system, until now considered a subject of physiological study?

The basic processes of the whole central nervous system are obviously identical—excitation and inhibition. There is sufficient reason to believe that the chief laws of these processes are irradiation and concentration and their reciprocal relations.

Concerning the cerebral hemispheres: with a slight tension of either the excitatory or inhibitory process, under the action of the corresponding excitation, irradiation carries the processes from the original point; with a moderate tension it is concentrated in the original point; and with marked tension, there is again irradiation.

Throughout the central nervous system on the basis of the irradiated excitation a summated reflex ensues, summated waves of the spreading excitation with local overt or latent excitation, in the latter case manifesting a hidden tonus—a well-known phenomenon. While in the cerebral hemispheres the meeting of the waves irradiated from different points quickly leads to the elaboration of a temporary connexion, the association of these points, in the rest of the central nervous system this meeting is a momentary and fleeting thing. The connexion arising in the cerebral hemispheres probably due to its developed reactivity is a constant and characteristic property of this part of the central nervous system. In the cerebral hemispheres, besides the irradiated excitatory process, the momentarily removed inhibition dissipates in turn, washes away, the inhibited negative points, giving these points for the time being a positive action. This phenomenon we term disinhibition.

During the irradiated inhibitory process there is observed a diminished and completely abolished action of the positive points and a reinforcement of the negative points.

When the excitatory and inhibitory processes concentrate they induce the opposite process (both at the periphery during the action and at the place of the action at its termination)—the law of reciprocal induction.

Over the whole central nervous system during the concentration of

[1] Several paragraphs dealing with old material concerning the conditioned and unconditioned reflexes are omitted.—*Translator.*

the excitatory process we meet with the phenomenon of inhibition. The point of concentrated excitation is surrounded by the process of inhibition—the law of negative induction. This phenomenon is manifested in all reflexes, it arises immediately and completely, continues for some time with the arrest of excitation and exists between small points as well as between the major divisions of the brain. We term it external, passive, unconditioned inhibition. This has also been known for a long time, sometimes as the conflict of the centres.

In the cerebral hemispheres besides this there are other forms or instances of inhibition, probably having the same physico-chemical substratum. In the first place is the inhibition which corrects the conditioned reflexes, mentioned above, arising when the conditioned reflex does not correspond to its unconditioned stimulus. It augments gradually, becomes reinforced and can be trained, perfected; all due to the extraordinary reactivity of the cortical cells with the consequent labileness of the inhibition in them. This inhibition we call internal, active, conditioned. The stimulus becoming transformed thus into a constant stimulator of the inhibitory state in the points of the cerebral hemispheres is inhibitory, negative. If indifferent stimuli are applied repeatedly during the inhibitory state of the cerebral hemispheres they may take on the character of such inhibitory stimuli (experiments of G. V. Volborth). The primitive inhibitory reflexes as is well known occur in the lower parts of the brain and also in the spinal cord, appearing here at once, being preformed, stereotyped; but the inhibitory reflexes of the hemispheres always can be seen to arise gradually, in process of elaboration.

There is in the cerebral hemispheres yet another kind of inhibition. Under all stable, equal conditions the effect of the conditioned stimulus runs parallel to the intensity of the physical strength of the stimulus up to (and also perhaps down to) a certain limit. Beyond the upper limit the effect does not increase but remains the same or lessens. We have reason to think that beyond the limit the stimulus together with the excitatory process evokes inhibition. For, in the cortical cells there is a boundary of capability (preventing exhaustion) beyond which arises inhibition. This limit is not constant but shows acute as well as chronic fluctuations—during fatigue, during hypnosis, illness and in old people. This inhibition, which may be called beyond the frontier, sometimes appears at once, at other times only with repeated ultramaximal stimuli.[2] It is admitted that this inhibition has an analogy in the lower parts of the central nervous system.

[2] I have rendered the Russian adjective for "beyond the frontier" into English as "transmarginal" or "ultramaximal" to represent stimulations which on account of their intensity produce an effect opposite to the normal stimulation.—*Translator.*

Individual internal inhibition may also be a transmarginal inhibition in the presence of which the intensity of the stimulation is modified.

Every inhibition irradiates like excitation, and in the cerebral hemispheres the movement of internal inhibition is especially marked and readily observed in its various degrees and forms.

Inhibition spreading and deepening results in various degrees of hypnosis, or with a maximum extension below into the brain, in normal sleep.

A functional dissociation can be observed in the lower parts of the brain as well as in the cortex. The motor area is especially frequently isolated from the rest of the cortex, and in this area there also occurs another functional separation.[3]

Unfortunately these facts have been confused with the so-called "sleep centre" of the clinicians and some experimenters. It is, however, not difficult to reconcile both sets of facts. Sleep has two methods of origin: the extension of inhibition from the cortex and the limitation of the stimulations falling on the higher parts of the brain both from within and without the organism. Strümpel produced long ago a case of sleep by a definite limitation of the external stimuli. Recently A. D. Speransky and Galkin by destruction of the peripheral defence, auditory and visual receptors in the dog produced a deep and chronic sleep lasting for weeks or months. Just so in pathological or experimental exclusion of stimulations gradually flowing into the higher part of the brain, thanks to the vegetative activity of the organism, there occurs a more or less prolonged and deep sleep. In several of these cases sleep evidently originates by virtue of inhibition resulting from the limitation of the stimulation.

With the concentration of the excitatory as well as of the inhibitory process the law of reciprocal induction begins to act. A point of concentrated inhibition is surrounded by a process of increased excitability—the phenomenon of positive induction. The heightened excitability arises either at once or gradually, and continues even for some time after the inhibition. Positive induction is manifested not only between shallow points of the cortex in the presence of divided inhibition but also between the larger divisions of the brain with extended inhibition.

By these laws we can clarify many phenomena appearing at first inexplicable. I shall mention here only one instance—that of the complex influence of foreign stimuli on the delayed conditioned reflex (experiments of our collaborator I. V. Zavadsky).

There is elaborated a delayed conditioned reflex by continuing the conditioned stimulus three minutes before it is reinforced by the unconditioned. During the first minute there is no evidence of the activity

[3] See chapters on hypnosis.—*Translator.*

of the conditioned stimulus, none till the middle or end of the second minute, with maximal effect in the third minute. Such a reflex consists of two external phases, the inactive and the active. Special experiments, however, indicate that the first phase is not inactive but inhibitory.

Now, if simultaneously with the conditioned reflex there are applied foreign stimuli of different intensities evoking only the orienting reaction, we observe a series of changes in the delayed reflex. With a weak stimulus the inactive phase is transformed into the active, and a special effect of the conditioned stimulus follows: the activity in the second phase remains unchanged or is slightly increased. With a stronger stimulus the first phase is unchanged but the effect of the active phases is notably lessened. With a very strong stimulus the first phase again remains inactive, the effect of the second entirely disappears. At the present on the basis of the most recent unpublished experiments of our co-worker, V. V. Rikman, we understand these phenomena as a result of the action of four laws: 1) the irradiated excitatory process, 2) negative induction, 3) summation, 4) limits. With a weak orienting reflex the extending wave of excitation removes the inhibition of the first phase; this reflex, quickly almost disappearing during the prolongation of the excitation, either makes the second phase inactive or in consequence of the slight summation reinforces it somewhat. With a marked orienting reflex its effect continues longer, because with the disinhibition of the first phase, thanks to a considerable summation of the active phase of the conditioned reflex with the irradiated wave of excitation of the orienting reflex, there arises transmarginal inhibition in the last minute of the delayed reflex. Finally with an intense orienting reflex there sets in a complete concentration of excitation from the strong negative induction, summating with the inhibition of the first phase and annulling the active phase.

In spite of the many studies we have made of the particular relations between excitation and inhibition, a general law of the relation of these processes can not yet be exactly formulated. Concerning the basic mechanism of the two processes much of our experimental material supports the view that the inhibition probably concurs with assimilation, and excitation, as is self-evident, with dissimilation.

We have certain data relating to voluntary movements. We, in agreement with earlier investigators, have shown that the motor area of the cortex is primarily receptor, like the visual, auditory and other regions; for from the kinesthetic stimulation of the motor cortex we can elaborate conditioned reflexes just as from external stimuli. Then there is the everyday fact, reproduced in our laboratory—the elaboration of a temporary connexion between any external stimulus and passive move-

ments, obtaining thereby definite active movements of the animal to certain signals. But entirely unexplained is how the kinesthetic stimulation is connected with its corresponding motor action: is it unconditioned or conditioned? Besides this final point the whole mechanism of voluntary movement is a conditioned, associated process, subject to all the described laws of the higher nervous activity.

On the cerebral hemispheres continually fall a multitude of stimulations both from the external world and from the internal medium of the organism itself. They are conducted from the periphery along special and numerous paths and consequently in the brain mass they fall upon definite points and regions. We have thus before us in the first place a complex structural mosaic. Along the conducting paths there are directed to the cortex varied positive processes, with which are connected in the cortex itself inhibitory processes. But from every separate state of the cortical cells (which states are also consequently numberless) may be elaborated a special conditioned stimulus, as we constantly see in our conditioned reflex studies. All these data should be classified and systematised. Before us, consequently, in the second place is a magnificent dynamic system. And in our conditoned reflex in the normal animal we observe and study this constant systematisation of the processes, the ceaseless striving, as it were, toward a dynamic stereotypy. Here is a remarkable fact worth relating. If we have formed in the animal a series of positive conditioned reflexes from stimuli of different intensities as well as inhibitory ones, and apply them for some time from day to day with definite and equal intervals between the stimuli and always in the same order, we establish in the hemispheres a stereotypy of processes. This is easily demonstrated. If now in the course of the whole experiment we repeat only one of the positive conditioned stimuli (better one of the weak) with the same intervals, then it alone produces in the correct order a fluctuation in size of the effects as represented by the whole system of different stimuli.

Not only the setting, but the more or less continued support of the dynamic stereotypy is a serious nervous task, depending upon the complexity of the stereotypy and the individuality of the animal. There are of course nervous problems so difficult that the nervous strength of the animal cannot solve them except after a tormenting struggle. Other animals with every simple change of the system of conditioned reflexes, or the introduction of a new stimulus, or only some alteration of the old stimuli, react with the loss of the whole conditioned activity, sometimes for a considerable period. Some animals tolerate the changed system only when the experiments are interrupted, *i.e.*, after a certain rest period. Finally others work regularly only with a fixed system of re-

flexes, consisting, *e.g.,* of two stimuli, with all positive and of equal intensity.

One may conjecture that the nervous processes of the hemispheres in the setting and support of dynamic stereotypy constitute what are usually called *feelings,* both positive and negative, with all the numerous gradations of intensity. The processes of the stereotyped setting, the consummated setting, the support of stereotypy and its destruction subjectively constitute our varied positive and negative feelings, which were always evident in the motor reactions of the animal.

All our work gradually forced us to the recognition of different types of nervous systems in our animals. As the cerebral hemispheres are the most reactive and highest part of the central nervous system, then their individual features should chiefly define the basic character of the general activity of any animal. Our systematised types coincide with the ancient classification of the so-called temperaments.

The best proof that our investigation of the higher nervous activity proceeds along the true path, that we accurately describe the phenomena, and that we correctly analyse their mechanism is that we can now in many cases functionally produce with exactness the chronic pathological condition and then at our desire restore it to normal. We know by what methods and which type of animals we can make neurotic and their treatment. Our experimental neuroses, it turns out, appeared in the strong but unbalanced excitatory and in the weak inhibitory types. If the excitatory animal is given problems requiring strong inhibition, then he almost entirely loses the inhibition, thus deprived of the capability of correcting the conditioned reflexes, *i.e.,* he ceases to analyse, to discriminate between the stimuli he meets. But the strongest excitations do not produce in him any pathological action. The weak inhibitory type however easily becomes ill from a slight tension of inhibition as well as from exceedingly strong stimulations, either failing entirely in our experimental setting to give any conditioned reflex activity, or going into a chaotic state. In animals of the balanced type we have been unable to produce nervous disturbances even by a collision of the opposite processes—an especially trying ordeal.

The best therapy against neuroses, in agreement with the findings of the clinic, are bromides, which according to our numerous and instructive experiments have a special relation to the inhibitory process, markedly reinforcing it. But the dose should be regulated accurately—for the strong type five to eight times greater than for the weak type. A rest by interruption of the experiments is frequently helpful.

Among animals of the weak type we frequently meet with natural neurotics.

We have already produced the distinct symptoms seen in psychotic patients: stereotypy, negativism, and cyclic manifestations.

Having become acquainted in the course of the present year with clinical hysteria, which is considered a mental disease wholly or at least chiefly, a psychogenic reaction to the surroundings, I became convinced that its symptomatology can be understood without striving toward an artificial schema, physiologically, from the point of view of the physiology of the higher nervous activity. This I have already published.[4] For only a few points of this symptomatology was it necessary to hypothesise how to supplement it in order to fit it into the higher nervous activity of the human being. This supplement is the speech function, the last new principle in the activity of the cerebral hemispheres. If our sensations and concepts relating to the surrounding world are for us the primary signals of reality, the concrete signals—then the speech, chiefly the kinesthetic stimulations flowing into the cortex from the speech organs, are the secondary signals, the signals of signals. They represent in themselves abstractions of reality and permit of generalisations, which indeed makes up our added special human mentality, creating first a general human empiricism, finally science—the weapons of the higher orientation of the human in the surrounding milieu and in himself. The extraordinary fantasy and imaginative state of the hysteric, but also the dreams of everyone, are an activation of the primary signals with their imagery and concreteness, and also emotions; when the beginning hypnotic state excludes chiefly the organ of the system of secondary signals as the most reactive part of the brain, always working mainly in the waking state and regulating, and inhibiting, to a certain degree, both the primary signals and the emotional activity.

Probably the frontal lobes are the organ of this added purely human mental function, for which, however, the general laws of the higher nervous activity must, one may conjecture, remain the same.

The above facts and considerations obviously should lead to the most intimate union of physiology and psychology, which already has been noted especially by a large group of American psychologists. In the speech of the president of the American Psychological Association for 1931, Walter Hunter, notwithstanding his forceful arguments for the behaviourist school, separates physiology from its psychology, thus vainly seeking some difference between them.

But psychologists even of the non-behaviourist school recognise that our experiments on conditioned reflexes are a considerable help, for example, in the work of the associative psychologists. Other similar instances could be given. I am convinced that an important stage of human thought will have been reached when the physiological and the

[4] See chapter LII.—*Translator.*

psychological, the objective and the subjective, are actually united, when the tormenting conflicts or contradictions between my consciousness and my body will have been factually resolved or discarded. Actually when the objective study of the higher animal, *i.e.*, the dog, reaches that stage—and this is being accomplished—in which the physiologists have an exact foreknowledge under all conditions of the behaviour of the animal, then what will remain of the independent separate existence of the subjective state, which of course is to the animal as ours is to us. Is not the activity of every living being, including the human, transformed for our thought into one indivisible whole?

CHAPTER L

AN EXAMPLE OF AN EXPERIMENTALLY PRODUCED NEUROSIS AND ITS TREATMENT IN THE WEAK TYPE OF NERVOUS SYSTEM

(Read at the VI Scandinavian Neurological Congress, Copenhagen, August 25, 1932.)

BROMIDES IN DIFFERENT TYPES OF DOGS—DESCRIPTION OF A CASE OF EXPERIMENTAL NEUROSIS.

At the International Neurological Congress in Berne last year I reported only the most general characteristics of our experimentally produced neuroses. Here I shall proceed to give an example of a neurosis which I have just now thoroughly studied with one of my oldest and most esteemed co-workers, M. K. Petrova.

When dealing with purely experimental neuroses we must begin with the question of types of the nervous system of animals (dogs). We differentiate three basic types: the strong, even very strong, and unbalanced; the strong and balanced, *i.e.*, with the two opposite processes at the same level; and the weak. . . . There are of course varying degrees or variations of these types especially of the weak. We have a considerable number of experiments by which we have gradually defined these types and their grades. A correct diagnosis of type can be made only after repeated experiments.

The purely experimental neuroses, obtained by giving difficult nervous problems, have appeared only in animals of the extreme types. With them this condition may be readily produced in several ways. I shall describe here a case of repeated neurosis in a dog of the weak type.

This dog was a mixture of cur with foxterrier, weight about 12 kgm. According to the external behaviour, the work with the conditioned food reflex, and according to several of our experiments on this type, this animal appeared in the beginning as a strong and balanced animal; but two further experiments convinced us that he belonged to the weak type: first, there was an increased food excitability (on the day before the experiment the dog went without food), and second the administration of large doses of bromide placed him in the weak group. In animals of the strong type with an increased food excitability usually either the effects of all the conditioned positive stimuli increases (if the effects of the strong are not transmarginal), or in the opposite case, only the effects of the weak approach the strong.

Large doses of bromides given daily for many weeks or months have proved in our hands to be free of any harm; and in the strong and

unbalanced types it even has a useful action, increasing their inhibitory function and then enabling them to regulate their nervous activity.

In our dogs both of these measures led to a diminution, to a destruction of the conditioned reflexes: the effects of the positive stimuli fail, but the negative continued to produce normal inhibition. In this case it was clear that with the gradually decreasing doses of bromide we could even improve the nervous activity. Formerly we came to an erroneous conclusion here: not regulating the dose of bromide correspondingly to the type, we thought that its administration in weak animals was never helpful and that in large doses it was injurious.

Thus our dog belonged to the weak type, but of moderate degree. Under the ordinary circumstances he works satisfactorily; a system consisting of six positive stimuli of different kinds and intensities and of one negative, applied daily in the same order and with equal intervals, always produces in this dog regular and correct responses. The behaviour of the animal during the experiment is more or less lively and equilibrated. In short it is a stable object for the study of conditioned reflexes. Such a condition was observed over a period of five months.

Now we produce the neurosis. Until now the inhibitory stimuli had acted only for thirty seconds. In the following experiment we prolong it for an entire five minutes. On another day we repeat the five minute inhibition, and this was enough to change radically the whole dog, to make him acutely ill.

Of the regularity of the conditioned reflexes there remains not a trace. Each day showed a characteristic picture. All the positive conditioned reflexes were markedly diminished, several completely disappeared. The inhibitory were disinhibited. Sometimes the ultraparadoxical phase set in, *i.e.,* the positive stimulus was inactive and the inhibitory one differentiated from it gave a positive effect. During the experiment the dog was extremely excitable, sometimes breathing vigorously, very restless, sometimes showing marked excitatory weakness, reacting to the slightest fluctuation of the environment. Frequently he refused the customary feeding given after each positive conditioned stimulus. In a word, concerning the work with conditioned reflexes there was no doubt of an extreme, chaotic condition of the nervous activity. The same was manifest in the behaviour of the animal. Putting the dog on the stand and preparing it for the experiment, and also removing it was not easy; for the animal was intolerant and uncontrollable. When free he conducted himself very strangely; when lying on the floor he would turn on his side and crawl up to some one, which he never did before. The *Diener* who took him to and from the kennel reported that he had become mad.

Neither interruption of the experiments (rest) nor substitution of the inhibitory stimuli by the positive had a beneficial influence. His condition, instead of improving, continued for two months to get worse.

Then we began the treatment. Thirty to forty minutes before each experiment we gave sodium bromide. On the second day there was a marked improvement and on the third day the dog was in all relations normal. The bromide was discontinued after the twelfth dose. For the next ten doses the animal remained completely well.

Now we pass to another experiment.

Together with the old positive conditioned reflexes in this dog, instead of the moderately loud noise, we applied for thirty seconds, like all the other positive conditioned reflexes, an exceedingly loud noise, even intolerable to our ears, and then we offered food. The animal gives a marked fear reaction, struggling from the stand and not taking food even at the cessation of the stimulus. However with the two following usual stimuli he reacts normally and takes the food. The application of the extraordinary stimulus was limited this time, but on another day the above described illness of the dog returned completely, and notwithstanding an interruption of ten to fifteen days and a regular rest of two days, his condition did not change for more than a month.

Now we again give the same dose of bromide as at first; the improvement was marked on the third day, and on the sixth to seventh days the animal was altogether normal. Bromide was discontinued after ten doses. Here the experiments were interrupted by the vacation period.

It is not an exaggeration, it seems to me, to say that these experiments have a machine-like character. It is evident that they represent two pathological moments for the nervous activity: the excessive tension of the inhibitory process and the very strong external stimulus. Then a salutary factor in both cases was the production and strengthening of the inhibitory process just as at the basis of many other of our experiments bromides have been shown to have a direct relation to the inhibitory process, both producing and reinforcing it. Finally, a most important part of the therapy is the exact dosing corresponding to the precise type of nervous system.

CHAPTER LI

DYNAMIC STEREOTYPY OF THE HIGHER PARTS OF THE BRAIN

(Read at the X International Psychological Congress, Copenhagen, August 24, 1932.)

DYNAMIC STEREOTYPY RESULTS FROM STIMULATION—RESULTS IN DIFFERENT TYPES—CONFLICT OF STEREOTYPIES—PHASES—ANALOGY TO FEELINGS—HUMAN CASE CITED.

Both from the external world and from the internal medium of the organism itself, an infinite number of stimulations varying qualitatively and quantitatively ceaselessly flow into the cerebral hemispheres. One of these (the orienting reflex) is under investigation—the others are known to have a varied unconditioned and conditioned action. All these occur, collide, react with one another, and they must finally be systematised and equalized, to end, as it were, in a dynamic stereotypy.

What a magnificent work!

However, a detailed and exact investigation depends primarily upon a favourable setting. We study this activity by a system of conditioned reflexes, chiefly the food reflex in dogs. The system consists of a series of positive stimuli of the different receptors and of various intensities, and also of negative stimuli.

As all these stimulations may leave some traces, exact and constant effects of the stimuli in the system can be obtained most readily by using fixed intervals between the stimuli, by applying them in a strictly definite order, *i.e.*, by an external stereotypy. The final result is a dynamic stereotypy,—the elaboration of the dynamic stereotypy is a nervous test of varying tension depending, of course, upon the complexity of the system of the stimuli on the one hand, and on the other hand, upon the individuality and state of the animal.

I shall take an extreme case (experiment of S. N. Vuirzhikovsky). In an animal with a strong nervous constitution, having a well elaborated stereotyped system of positive conditioned stimuli of varying intensities and of negative conditioned stimuli, a new stimulus was introduced with this modification—it was applied after different conditioned stimuli, four times in the course of the experiment, accompanying it with the unconditioned stimulus only on the fourth application. Although the reflex was quickly elaborated, the animal became correspondingly excited, struggling on the stand, tearing off all the apparatus, barking; the former positive conditioned stimuli lost their action, terminating in refusal of the proffered food; the animal was with

difficulty brought into the experimental camera. This disturbed state lasted all of two to three months during which the dog was unable to solve the problem; a stereotypy was set up, the first three applications of the new stimulus gave a negative instead of a positive action, and only the fourth application had a positive effect during which the animal was entirely quiet.

The establishment of the new dynamic stereotypy represented an enormous nervous load which only a strong type of nervous system could tolerate.

Our experiment was continued. After the first problem was solved, the animal was confronted with another. The first three applications of the new stimulus were now reinforced with food, *i.e.*, the animal had to change them from inhibitory into positive. During the first experiments the animal was excited but less intensely and for a shorter time, and all the applications of the new stimulus did not give the same positive effect. This means that with the reorganisation, the stereotypy ceased to be a difficult task. Food now being given, there was no longer inhibition of the food excitation, as was probably partly the case in the first problem, especially in the establishment of the new dynamic stereotypy in the cerebral hemispheres. The fact that the organisation now proceeded more smoothly and easily came about as a result of the greater stability of the second problem. The simpler system of conditioned reflexes was elaborated by the same animal more readily and certainly without any of the signs of tension seen previously.

It would seem strange to me if because only associative activity is ascribed by the psychologists to the dog, this nervous task should not be considered as a mental one.

Such are the circumstances only in the strong and equilibrated nervous systems. With the strong and unbalanced, in the more or less weak, ill, exhausted, aged, it is another matter. There are dogs in whom from the very beginning, in spite of favourable conditions, a dynamic stereotypy is impossible; the effects of the conditioned stimuli fluctuate chaotically from experiment to experiment. In such an animal a stable system of reflexes may be formed using only two stimuli, both of which are positive. An alteration of the order of the old stimuli in the experiment is not an easy task, leading sometimes even to a complete temporary cessation of our conditioned reflexes. But the maintenance of a system already elaborated is also work, which some dogs tolerate only by an interruption of the experiments every two or three days, *i.e.*, regular rest; if the experiments are performed daily the conditioned reflexes fluctuate in every irregular way possible.

The established stereotypy of processes in the cortex can be clearly seen in the absence of the actual stimuli (Krzhishkovsky, Kupalov,

Asratian, Skipin, Gantt, and others). Here is an interesting experiment. If we have a series of elaborated conditioned reflexes, positive of different intensities as well as negative, the intervals between them being not the same but constant from day to day, applied in a fixed order, and then if we use only one of the positive (preferably a weak one), we obtain the following results. This stimulus in the course of the experiment gives a fluctuating effect corresponding to the whole system of different stimuli. The old stereotypy persists for some time before the new sets in, reaching a uniform effect finally by repetition of the single stimulus. But this rôle of the old stereotypy, once it is fixed, does not end here. If the last stimulus, after not being applied for some days, is tried anew, we obtain the old and not the new stereotypy. Consequently there are several strata of competing stereotypies.

Another interesting fact was observed. When the hypnotic state sets in during the experiment (which it frequently does in certain dogs where one stimulus is used alone, especially if that be a weak stimulus), then the stimulus applied alone instead of the whole former system reproduces the system but in reverse: in the place of the former strong stimuli there is a weak effect, and in the place of the weak ones, a strong effect—paradoxical phase. This phase has been observed by us for a long time with stimuli of various intensities during hypnosis. Thus in the case cited the hypnotic state and the dynamic stereotypy are combined.

There is reason to think that the described physiological processes in the cerebral hemispheres correspond to what we subjectively call in ourselves, *feelings,* in the general form of both positive and negative, with innumerable shades and variations, thanks to either their various combinations or their different tensions. Here belong the feelings of difficulty and facility, alertness and fatigue, gratification and vexation, joy, triumph and despair, etc. Frequently, it seems to me that the depressed feelings experienced by a change in the customary mode of living, such as loss of a position or of loved ones, to say nothing of mental crises and shattered beliefs, have their physiological basis to a large extent in the changes, in the destruction of the old dynamic stereotypy with the difficulty of establishing a new one.

A prolongation of such cases with great tension may even result in melancholia. A vivid case recalled from my student days comes to mind. Entering the University I and three comrades from the secondary school selected under the influence of our early literary inspiration the department of natural sciences—chemistry, botany, etc.—consisting chiefly until that time in the assimilation of separate facts. While two of us reconciled ourselves to this, the third, who in the secondary

school found special pleasure in his study of history, particularly in the written exercises concerning the causes and results of various historical events, became gradually sadder and finally deeply melancholic and suicidal. His condition improved only when we, his comrades, began to take him, at first with great difficulty, almost forcefully to the lectures in the law school. After several of these his mood changed notably, and finally he became completely normal. Then he transferred to the department of law, successfully completing it and remaining normal all through his life. Conversations prior to his illness and after its inception made us think that our comrade, having become accustomed in his school work to associate easily separate phenomena, tried to do the same in the natural sciences. But these unassimilated facts continually opposed his tendencies, not allowing him to do what he had been able to do with the literary material. These repeated failures resulted in a depressed mood and a pathological form of melancholia.

And in our dogs confronted with difficult problems, *i.e.*, requiring a new dynamic stereotypy, there was not only a state of anxiety, as described above, but also there was produced a chronic nervous condition—a neurosis which we were able to relieve by proper treatment.

CHAPTER LII

AN ATTEMPT TO UNDERSTAND THE SYMPTOMS OF HYSTERIA PHYSIOLOGICALLY

(The Academy of Sciences of the U.S.S.R., Leningrad, 1932. Dedicated to my esteemed and respected comrade, Alexei Vasilievich Martuinov, on the fortieth year of his scientific, professorial, and practical activity—by the grateful author.)

PHYSIOLOGY OF CONDITIONED REFLEXES—TRANSMARGINAL EXCITATION—ACTIVE AND PASSIVE SLEEP—HYSTERIA PHYSIOLOGICALLY CONSIDERED—EXPERIMENTAL CASE—CLINICAL HYSTERIA—CORTICAL WEAKNESS—SUGGESTION—NEGATIVE INDUCTION—SENILE DISTRACTION—A CASE OF WAR NEUROSIS—ANALGESIA AND PARALYSIS—AUTO-SUGGESTION—ARTISTS AND THINKERS—FRONTAL LOBES—SPEECH SYSTEM—HYSTERICAL PUERILISM—PHYSIOLOGICAL TREATMENT OF HYSTERIA.

Although hysteria is classified by all clinicians as a psychiatric disease wholly or chiefly, a psychogenic reaction to the surroundings, the objective study of the higher nervous activity by the conditioned reflex method has so advanced, broadened and deepened that I do not consider it very risky to attempt physiologically to understand, to analyse such an intricate pathological picture as hysteria in all of its manifestations.

Thus this will be a physiological explanation of the so-called psychical phenomena—an aspiration of the conditioned reflex investigations.

Unfortunately here is necessary some physiological introduction. Even on my native soil conditioned reflexes are not well known, and, too, the study has developed so rapidly that many of the most important facts have not yet been published, appearing here for the first time.

I.

The first third of this article will deal with the origin of conditioned reflexes, their value as signals, the two processes of excitation and inhibition, and their irradiation and concentration.[1] When the processes of excitation and inhibition concentrate they induce the opposite process in the periphery during the action as well as at the site of the activity after its cessation. Thanks to the irradiation of the excitatory process, summation of reflexes occurs. A wave from a new excitation, having spread, summates with the existing local excitation, kinetic

[1] Although these topics have been treated before, some new material is added here. I have made certain condensations and omissions.—*Translator.*

or potential, in the latter case becoming a hidden focus of excitation. In the cerebral hemispheres on account of the complex structure and great reactivity, the irradiated process leads to the elaboration of a temporary conditioned connexion, an association. While a summated reflex is momentary and transitory, the conditioned reflex is gradually reinforced to become a chronic manifestation, a characteristic process of the cortex.

With the concentration of the excitatory process along the whole extent of the central nervous system, inhibition appears—the law of induction. The point of concentrated excitation is surrounded by the process of inhibition—a phenomenon of negative induction, seen with unconditioned as well as conditioned reflexes. The inhibition is deeper, broader and lasts longer the stronger the excitation and the less the positive tone of the surrounding nervous tissue. Negative inhibition acts between small points as well as large divisions of the brain. This inhibition is external, passive and unconditioned, as we call it. Formerly this was referred to as a conflict of nerve centres.

In the cerebral hemispheres in addition to the above form of inhibition, there is another, although there is reason to think that the same physico-chemical process underlies both. The kinds of internal inhibition are chiefly those of extinction and differentiation. It is an active inhibition. It is important to note that above a certain limit of intensity an excitatory stimulus produces inhibition, which might be called transmarginal or ultramaximal.

The limit of ability of the cortical cells is not constant, showing both acute and chronic fluctuations: during exhaustion, hypnosis, disease and senility the limit constantly falls, and the environment is now more often "transmarginal" with resulting inhibition. Also when normally or artificially, as chemically, the excitability is raised, then the more the formerly submaximal and maximal excitations are converted into ultramaximal, leading to inhibition and a general lowering of the conditioned reflex activity. There remains the unsolved question, how are the last two cases of inhibition related to the first universal instances of negative induction? If they are actually only a variation how does this inhibition become a peculiarity of the cortex? Probably frontier, *i.e.*, ultramaximal, inhibition is nearer to the inborn external passive inhibition than to the internal active, as it arises immediately and without elaboration or training.

Both of these cortical inhibitions spread over the nervous tissue, evoking, according to their different degrees, hypnosis, or during the maximal extension, normal sleep. Light hypnosis, the equivocal, paradoxical and ultraparadoxical phases, is hardly distinguishable from the waking state.

Unfortunately the results of our experiments have not been brought into correlation with the so-called sleep centres of the clinicians and certain physiologists. But it cannot be doubted that there exist two mechanisms of sleep, and one must distinguish between *active* and *passive* sleep. The former proceeds from the cerebral hemispheres and is based upon active inhibition, spreading from its origin to the underlying parts of the brain. Passive sleep originates as a result of decreased excitatory impulses falling upon the highest parts of the brain, not only on the cerebral hemispheres but on the underlying subcortex.

The excitatory impulses may be external, reaching the brain through the external receptors, or internal, conditioned by the work of the viscera and coming to the higher parts of the brain from the central nervous regions regulating the vegetative activities. The first case of passive sleep has long been known from the clinical report of Strümpell; it is analogous to a recent fact from the experiments of Speransky and Galkin, when after peripheral destruction of three receptors (the auditory, visual and olfactory) the dog falls into a profound and chronic sleep lasting for weeks and months. The second instance of passive sleep is the clinical one, leading to the recognition of the so-called sleep centre of the clinicians and certain experimentalists. We have an analogous example in the muscle tissue. Under special physiological conditions the skeletal muscle contracts actively and relaxes actively—under a stimulation of two special nerves, the excitatory and the inhibitory.

Precisely during the concentration of both the excitatory and of the inhibitory processes appears the opposite process (the law of reciprocal induction). Positive induction is known with both unconditioned and conditioned reflexes, appears either immediately or for some time after the inhibition.

Now I shall touch upon certain facts significant for the physiological analysis of the symptoms of hysteria. The connexions of the organism with the surroundings through the conditioned signals is the more perfect the more the cerebral hemispheres analyse and synthesise the signals corresponding to the extreme complexity and continued fluctuations of the surroundings. Synthesis is accomplished by the process of conditioned connexions. Analysis, differentiating the positive conditioned signals from the inhibitory, is based upon the process of reciprocal induction; the separation of the various positive agents, *i.e.*, unions with the various unconditioned reflexes, occurs by virtue of the process of concentration (recent experiments of V. V. Rikman). Thus for an exact analysis a certain tension is required of the inhibitory as well as of the excitatory process.

Of specific significance for the physiological study of hysteria are

our facts relating to the types of nervous systems. First we have the very strong animal, albeit unbalanced, in which the inhibitory process is considerably weaker than the excitatory. In the face of difficult problems necessitating great inhibition, these animals lose nearly altogether the inhibitory function (a special neurosis) and become extremely restless and agitated, sometimes with periodic drowsy or depressive states. In their general behaviour they are aggressive, animated, undisciplined. We call such animals excitatory or choleric.

Next follows the strong but balanced type where both processes stand at the same level. This is why it is impossible through giving hard tasks to produce in such animals a nervous disturbance. This type occurs in two forms: the quiet (phlegmatic) and the very lively (sanguine).

Finally there is the weak inhibitory type in which both processes are insufficient, especially the inhibitory—a type easily produced experimentally and particularly subject to neuroses. They are in constant fear and anxiety. They cannot endure intense external stimuli in the form of positive conditioned stimuli, nor much normal excitation (food, sexual), nor a prolongation of the inhibitory process, nor a collision of the nervous process, nor a complex system of conditioned reflexes, nor finally a change in the stereotypy of the conditioned reflex activity. Under such circumstances the conditioned reflexes become weaker and chaotic, and many of these animals fall into the hypnotic state. There may be easily produced in them separate pathological points in the cerebral hemispheres, which when touched, result in a rapid deterioration of the conditioned reflexes. If judging by the external behaviour, it is not always appropriate to call these animals melancholic, they may nevertheless be placed in the group of melancholics, *i.e.,* with those animals who seem to be constantly inhibited. Explaining these types from the point of view of a balance between excitation and internal inhibition, we feel that in the weak type on account of the weakness of the internal inhibition, the external inhibition (negative induction) on the other hand predominates and determines the whole external behaviour, hence the name of this type—the weak inhibitory.

In concluding the physiological part I should call attention to the following difficulty, especially important for the understanding of some of the extraordinary symptoms of hysteria. Not only from the skeletal motor apparatus proceed centripetal, afferent impulses from every element of movement to the motor area of the cortex, making possible the exact control of movement by the cortex, but indeed from the other organs and even from the individual tissues, whence the cortical control over them. At present this intricacy—and it must

be connected with the higher parts of the central nervous system—has a wide biological significance once it is proven that leucocytosis, immunity and other organic processes can be conditioned, although we do not yet know exactly the nervous connexions, participating directly or by some indirect way.[2] Only this latter possibility of action from the cortex is voluntarily utilized and expressed by us very rarely under exceptional, artificial or abnormal circumstances.[3] The cause of this is, on the one hand, that the activity of the organs and tissues other than the skeletal musculature is automatically regulated chiefly by the lower parts of the central nervous system, and on the other hand, marked by the main function of the cerebral hemispheres directed to the intricate relations with the external environment.

II.

Let us return to hysteria. The general clinical descriptions of hysteria include those concerning the basic characteristics of the condition as well as the special symptoms. Some clinicians speak of the reversion to the instinctive, *i.e.*, emotional and even reflex life, others describe the disease as resulting from suggestibility and autosuggestion with the consequent so-called stigmata of hysteria (analgesia, paralysis, etc.); some see the disease primarily as voluntary, a retreat into illness; some ascribe to it fantasy, an absence of reality in the relation to life; others consider hysteria as chronic hypnosis; and finally there are those who propose a diminished function of psychical synthesis or a destruction of the integrated "inhibition." One may presume that together these symptoms include the whole symptom-complex of hysteria.

First one must recognise hysteria as a production of a weak nervous system. Pierre Janet states that hysteria is a psychical disorder belonging to the immense group of diseases resulting from weakness and exhaustion of the brain. If this is true then the described characteristics of hysteria as a weakness related chiefly to the higher part of the central nervous system and especially to the cerebral hemispheres, the most reactive of its parts, are comprehensible in the light of the physiology of the higher parts of the central nervous system as it is represented by the knowledge of the conditioned reflex.

Usually the cerebral hemispheres, as the highest organ of correlation of the organism with the surrounding medium and consequently a continual controller of supplementary functions, constantly restrains the other parts of the brain with their instinctive and reflex activity.

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[2] For a discussion of this see: Gantt, Katzenelbogen and Loucks: Bull. Johns Hopkins Hospital, June, 1937.—*Translator*.

[3] Here might be classified such phenomena as hysterical pregnancy and stigmata. —*Translator*.

Hence with the strained and weakened cerebral activity, there goes a more or less chaotic function of the subcortex, deprived of its corresponding relation to the cortex. This is a generally known physiological fact seen in animals after extirpation of the cerebral hemispheres, in adult people under the influence of various narcotics, and in small children during the transition from the waking state to sleep. Thus speaking in the above established physiological terms, the waking active state of the cerebral hemispheres consisting in the continual analysis and synthesis of the external stimuli, the active surroundings, produces negative induction in the subcortex, *i.e.,* generally restrains its functions, freeing selectively only that of its work requiring a conditioned place and time. Conversely, the restraining, inhibitory state of the cerebral hemispheres liberates, it seems, positive induction of the subcortex, *i.e.,* intensifies its general activity. Consequently (this is a justifiable physiological basis) in the hysterical patient during acute restraint of the cortex under the influence of intolerably strong stimulations, and on account of its weakness these are numerous—there resulted various affective splits and convulsive seizures, now in the form of more or less definite instinctive and reflex actions, now completely chaotic, correspondingly localised by the mobilisation of inhibition in the cortex and subcortex, now in the neighbouring, now in the more distant parts.

But this is an extreme and active expression of the illness. When the inhibition spreads deeper into the brain we have another extreme, but passive state of hysteria in the form of profound hypnosis and finally complete sleep lasting not only hours but for many days (lethargy). This difference between extreme states is probably determined not only by the various degrees of weakness of the processes of excitation and of inhibition in the cortex but by the established relations between the cortex and subcortex, now changing acutely and chronically in the same individual, now connected with different personalities.

Besides the fact that a varying, chronic, cortical weakness is the basis for the manifestation of the above described extraordinary states of the organism, this weakness inevitably conditions a constant special state of the hysteric. This is *emotionability.*

Although the life of animals as well as our own is directed to the basic tendencies of the organism—food, sexual, aggressive, investigative, etc. (functions of the underlying subcortex)—nevertheless for the perfect agreement and correlation of all these tendencies in connexion with the general circumstances of life, there is a special part of the central nervous system which measures every separate tendency, corre-

lates them and secures their advantageous realisation in connexion with the environment. This of course is the cerebral hemispheres. There are two methods of action. After a preliminary survey, so to speak, (sometimes arising almost instantaneously) of the given tendency of the cerebral hemispheres and its transmutation, in the proper degree and at the corresponding moment, into the corresponding motor act or behaviour by means of the motor cortical area—this is the reasoned action; and the action (perhaps directly through the subcortical connexions) under only the influence of the tendency without that preliminary control—this is the affective, emotional action. In the hysteric it is this second action that predominates and by a well understood nervous mechanism. The tendency arises as the result of an external or internal stimulus. To it corresponds the activity of the known point or region of the cerebral hemispheres. This point under the influence of emotion, subsequent to irradiation from the subcortex, is heavily charged: and with a weak cortex this is enough to produce an intense spreading negative induction excluding the control of the rest of the cerebral hemispheres. But there, in those parts representing other tendencies, are the representatives of the surroundings, traces of past stimulations and experiences. Here is connected another mechanism. The strong stimulation of emotion raises the excitability of the cortex, quickly leading to stimulation to the limit and beyond the limit of its capacity. Therefore the negative induction summates with the ultramaximal inhibition. Thus the hysterical patient lives, more or less, in an unreasoned and emotional life directed by the subcortical rather than by the cortical functions.

Suggestion and autosuggestion stand in direct relation with the above mechanism of the hysteric. What is suggestion and autosuggestion? They are a concentrated excitation of a definite stimulation, sensation or its trace, a representation, now in evoked emotion, *i.e.*, excited from the subcortex, now produced from without, now arising from an internal connexion, an association, excitation, having been given a predominant, "illegitimate" and irrepressible significance. It exists and acts, *i.e.*, passes over into movement in one or another motor act because it is reinforced by all the associations, *i.e.*, by the connexions from many present and past stimulations and representations—then this is an established and logical act if occurring in the normal healthy cortex; but because it exists in a weak cortex with a lowered tonus it becomes concentrated and is accompanied by an intense negative induction, cutting it off, isolating it from all foreign, unnecessary influences. Such is the mechanism of hypnotic and posthypnotic suggestion. In hypnosis and in the normal cortex we have a diminished

positive tonus as a consequence of irradiated inhibition.* When on such a cortex a work or order of the hypnotiser is directed to a definite point this stimulus concentrates the excitatory process in the corresponding point and is immediately accompanied by negative induction, which causes it without the slight opposition to spread over the whole cortex; this is why the word or order is completely isolated from all influences and is made an absolute, irrepressible, fatally-acting stimulus, even after the subject has returned to the waking state.

The mechanism is exactly the same, varying only in degree, arising in old age as the excitatory processes of the cortex naturally decrease. In the brain which is yet strong the external and internal stimulations concentrate to some degree (extremely only exceptionally) in a definite cortical point or region, accompanied of course by negative induction, but thanks to the strength of the cortex it is not complete and at some distance inhibition is extending. Therefore together with the chief excitation another one is acting to a certain degree to evoke the corresponding reflexes, especially the old established so-called automatic ones. Ordinarily in our behaviour we react not singly, but complexly, to fit the ever present contents of our environment. In old people the matter is altogether different. Concentrating on one stimulus we exclude by negative induction other collateral and simultaneous stimuli because they often do not suit the circumstances, are not complementary reactions in the given setting.

Let me give a minor incident of this. I look at some object which I need, take it and do not see anything touching or near it—this is why I unnecessarily strike against surrounding objects.[4] This is erroneously called senile distraction, on the contrary it is concentration, involuntary, passive, defective. Thus the old man, dressing and at the same time thinking about something or talking to someone, goes out without his cap, takes the wrong article, leaves his clothes unbuttoned, etc., etc.

In consequence of foreign and unpremeditated suggestions and also autosuggestion the life of the hysteric is replete with every possible eccentricity and invention.

Let us begin with a war neurosis, common since the World War. War as a continued serious threat to life naturally creates the fear

* Notwithstanding the mass of pertinent material in the physiology of the central nervous system in general and in the study of the conditioned reflexes in particular the relation between excitation and inhibition remains a question as yet unsolved. What are they? Are they one and the same, transferred one into the other in a definite setting, or a strongly united pair reversed under certain circumstances and presenting now in part now fully one or the other of its sides?

[4] Pavlov often noted and called attention to these senile tendencies in himself. He wrote this article at the age of 83. Although he may have been able to observe certain symptoms as failing memory, to others he remained a picture of energy and alertness.—*Translator.*

impulse. Fear represents certain physiological symptoms which in those having a strong nervous system either simply do not appear, are suppressed or quickly dissipated, but in weak people they last for some time making them unfit for further military participation, thus freeing them from the necessity of endangering their lives. These symptoms may disappear of themselves in time, but in the weak nervous system precisely on account of this weakness, there is added the reinforcement of their mechanism. The symptoms of fear become connected, associated, with security to life by the law of conditioned reflexes. Hence the existence of these symptoms is invested with a positive emotional colouring and repeatedly reproduced. Then according to the law of irradiation and summation from the cortex they reinforce and intensify the lower centers of reflex symptoms of fear on the one hand, and on the other hand being emotionally charged, in the weak cortex accompanied by strong negative induction, they thus exclude the influence of other representations which might oppose the representation of the conditioned pleasantness or desirability of these symptoms. Therefore sufficient justification does not remain for us to say that in the given case there is an intentional simulation of symptoms. It is an example of fatalistic physiological relations.

Such cases in hysterics and in ordinary life are numerous. Not only the threat of war but many other dangers for life (fire, railroad wrecks, etc.), the countless blows of fate as the loss of loved ones, disappointment in love and the other vicissitudes of life, economic reversals, and the devastation of one's beliefs and faith, etc., and in general hard living conditions: an unhappy marriage, the struggle with poverty, the destruction of the feeling of self-respect, etc., evokes at once or finally in the weak person the strongest reaction with various abnormalities in the form of somatic symptoms. Many of these symptoms having arisen in a moment of strong excitation are imprinted on the cortex for a long time or permanently, like many intense stimulations in normal people (kinesthetic similarly to all others). Different symptoms, capable of acting in the normal subject, are in them obliterated, in consequence of a fear that they might be abnormal, or awkward, harmful or even only indecent; or conversely, for some advantage, or simply for the sake of an interest, by the same mechanism as in the above war case, emotionally reinforced they become more and more intense and extensive (on account of irradiation) and stable. Obviously in a weak person who is a living invalid incapable in a positive way of demanding attention, respect, good will, the motive to obtain these will function to continue and reinforce the pathological symptoms. Hence the flight, the will to be sick as a most characteristic feature of hysteria.

Together with these positive symptoms are also negative ones, *i.e.*, those produced in the central nervous system not by the process of excitation but by the process of inhibition, such as analgesia and paralysis. They demand especial attention, and several clinicians, *e.g.*, Hoche in a recent article, consider certain hysterical symptoms absolutely incomprehensible. But this is illogical; for these symptoms are not different from the positive. Do we normal subjects always restrain our definite movements and words, *i.e.*, send the inhibitory impulse to the proper areas of the cerebral hemispheres? In the laboratory as I have pointed out in the physiological introduction, we continually elaborate with the positive conditioned stimulations also inhibitory. In hypnosis by a word-stimulus we produce anesthesia, analgesia and inability to move and in some instances paralysis. But the hysterical patient often can and must be considered under the ordinary circumstances of life as chronically hypnotised to a certain degree; for to his weak cortex usual stimuli are ultramaximal and are accompanied by an overflow of transmarginal inhibition just as we see it in the paradoxical phase of our hypnotised animals. Then in addition to the established inhibitory symptoms, similar to the positive ones arising at the moment of a severe nervous trauma, these inhibitory symptoms can be produced in the "hysteric-hypnotised" subject by suggestion and autosuggestion. All representation of an inhibitory effect, whether from fear, interest or of an advantage to be gained, is concentrated and intensified repeatedly in the cortex as a result of the emotionality of the hysterical patient just as in hypnosis the command of the hypnotiser evokes and establishes these symptoms for a long time, while finally the more intense waves of excitation in any case do not touch these inhibitory points.

By the same mechanisms autosuggestion in hysteria brings up many other symptoms both ordinary and extraordinary.

Any slight feeling of indisposition or unusual difficulty in any organic function is accompanied in the hysteric by the emotion of fear of a serious illness, and this is enough, by the above mechanism, not only to support but to intensify them to an extreme degree, making of the subject an invalid. Only in this instance the cause of its spreading and dominating action in the cortex is not a positively coloured sensation as in the war neurosis but a negative one. Of course the nature of the physiological process is unimportant. One of the peculiar cases of hysterical autosuggestion is that of fictitious pregnancy with the corresponding changes in the mammae and increased fat in the abdominal wall, etc. This is an additional confirmation of what was stated in the first part of the article concerning the representations in the cortex of not only the activities of all the organs but even

give it life in order that they might also succeed. This difference is especially prominent in the so-called eidetic imagery of children. Here I remember an astonishing case that occurred forty to fifty years ago. In a certain family with an artistic leaning there was a child two or three years old whose parents among other things diverted him and also themselves by giving him to pick over a collection of twenty or thirty photographs of their relatives, writers, artists, etc., naming each one to him. The result was that he called them all correctly. What a general amazement there was when accidentally he also named them correctly, taking them in his hand from the nurse. Evidently in this case the cerebral hemispheres receive the visual stimuli exactly as the variations of intensity of the light in a photographic plate, just as a phonographic record is made from sound. Indeed this is, some may think, a characteristic of all types of artists. Such a whole creation of reality cannot be completely attained by a thinker. This is why it is so exceedingly rare that there is united in one person a great artist and a great thinker.[5] They are usually represented by separate individuals. Of course the average person occupies a middle position.

It seems to me that there are strong physiological reasons, although not entirely convincing, to understand the matter thus. In the artist the activity of the cerebral hemispheres flowing through the whole mass, involve least of all the frontal lobes, concentrating chiefly in the remaining parts; in the thinkers, however, the converse is true.

The total integrity of the higher nervous activity I represent thus. In the higher animals, including man, the first mechanism for the complex correlation of the organism with the surroundings is the neighbouring subcortex with its intricate unconditioned reflexes (our terminology), the instincts, urges, affections, emotions (the usual terminology). These reflexes, *i.e.*, inborn activities, are called out by only a few unconditioned external agents. Hence the limited orientation in the milieu and with it a weak adaptation. The second step in the correlation is made by the cerebral hemispheres, but without the frontal lobes. Here arises with the help of the conditioned connexions, associations, a new principle of activity: the signalisation of a few unconditioned external agents by numberless other agents, constantly analysed and synthesised, making possible an extremely varied orientation in the same milieu and a much greater adaptation. This constitutes a unified signalising system in the animal organism and primarily in the human. In the latter there is added, possibly especially in the frontal lobes, which are not so large in the animal, another system of signalisation, signalling the first system—*speech,* its basis or fundamental components being the kinesthetic stimulations of the speech organs.

[5] Goethe and Leonardo da Vinci are examples.—*Translator.*

Here is introduced a new principle of higher activity (abstraction— and at the same time the generalisation of the multitude of signals of the former system, in its turn again with the analysis and synthesis of these new generalised signals), the principle of the conditioning limitless orientation in the surrounding world and of creating the highest adaptation of the human—science both in the form of a humanitarian empiricism as well as in its specialised form. This second system of signalisation and its organ, the very last attainment in the evolutionary process, should be particularly fragile, supported in the first instance by overflowing inhibition, once it has arisen in the cerebral hemispheres in the primary degrees of hypnosis. Then instead of the usually predominant (in the waking state) function of the second signalising system, there arises the activity of the first system, primarily and more stably as fantasies and day dreaming, but further and more definitely as sleep, dreaming, and drowsiness, freed from the regulating influence of the second system. Hence the chaotic character of this activity depending chiefly upon the emotional influence of the subcortex.

On considering all the above facts, from the physiological point of view it is easy to understand the clinical expressions applied to hysteria, destruction of psychical synthesis (Pierre Janet) or splitting of the "inhibition" (Raymond). Instead of a united and equally reciprocating activity of the three above mentioned systems in hysteria we have a continued separation of these systems with a marked disorgansation of the natural and lawful correlations, when in connexion with and in obligatory co-dependence of the work of these systems is the healthy personality, the integrity of our "inhibition."

As a final result, due to the weakness of the cerebral hemispheres in the hysteric there is a continual manifestation in different combinations of three special physiological phenomena: the readiness with which the hypnotic state occurs because even the habitual daily stimulations are ultramaximal and are accompanied by transmarginal overflow of inhibition (paradoxical phase), the extreme fixation and concentration of the nervous processes in separate points of the cortex, thanks to the predominance of the subcortex, and finally the extraordinary intensity and extension of the negative induction, *i.e.*, inhibition in consequence of the reduced positive tonus of the other parts of the cortex.

In conclusion I shall mention the hysterical psychoses, a case (hysterical *puerilism*) which was demonstrated to me. A woman of forty or more years became ill from shocks arising in her family life. At first the husband was suddenly arrested, and then some time after the husband had returned the child was taken away. After an attack of

tetanus with a prolonged paresis she became puerile. She behaved as a child although she did not show general mental, ethical, and social deterioration. Looked at more closely, there is absence only of the more stable and constant accompaniments of our behaviour, the particular movements, words and thoughts, inhibitions which differentiate the adult from the child. Does not our growth consist in that, under the influence of education, of the religious, social, and governmental requirements, we gradually inhibit, restrain ourselves from doing what is not permissible, prohibited by, the above forces? Do we not in the family, with friends, conduct ourselves in all relations otherwise than in different situations? Indeed these are living universal experiments which undoubtedly prove this. Do we not see constantly how a person under the influence of strong emotion, of predominating higher inhibitions, speaks and does that which he would not allow himself to do when undisturbed and which he bitterly regrets when the effect vanishes? And is this not obvious among the intoxicated, where there is a marked exclusion of inhibition, so well expressed in the Russian proverb—to the drunk man the sea is only knee deep?

Does this state pass over into the normal? Perhaps and perhaps not. During youth, according to the psychiatrists, this may linger for hours and days, or may continue longer. In the given case this state was one of relative calmness and satisfaction. Here may act the nervous mechanism described above in the form of escape through illness from the burdens of life, finally becoming an ineradicable habit. But on the other hand, the disturbed, tensed inhibition may irrevocably weaken, vanish.

From the physiological point of view can hysteria in general be treated? Here all depends upon the type of nervous system. The predominating and most stimulating impression from our work with the conditioned reflexes on dogs is that it can. This opens wide possibilities for the training of the cerebral hemispheres, but of course there is a limit. Once we have an extremely weak type, here in the presence of the exclusive setting of the experiment (as we say in the laboratory) it is possible to improve and regulate the general conditioned reflex activity of the animal but no more. There can be no question of transformation of the type. But as the separate hysterical symptoms, being general physiological reactions with extremely strong stimulations, from the severe shocks of life, are encountered in the more or less strong types, here a complete return to normal is possible; however only when the series of these shocks and extreme tensions do not exceed a limit.

While it is with absorbing interest that one reads the brilliant article of Kretschmer on hysteria, showing a decided inclination of the author

toward a physiological conception of the hysterical symptoms, the recent paper of Hoche in the January, 1932, number of the *Deutsche Medizinische Wochenschrift* produces a strange impression. Really do not contemporary physiological data cast the slightest ray into the mechanism of hysteria, actually does the clinic and physiology "stand before hysteria as before a closed door"? Oddly enough Hoche's point of view is as follows: Assuming hysterical analgesia and paralysis are the fundamental features of the disease, he asks the advocates of the theory of the pathological force of motives in hysteria, why does not the intense indignation of some of his readers and listeners against his opinion of this theory make them insensitive to pain as if he gave them a severe electric shock? Then follows another similar instance; why, for example, do people not cure themselves by a strong desire to be rid of their disease, their neuralgia? But here I recall from my student days the following fact, astonishing to me and many others. A young woman underwent a plastic operation on the nose, which had been frightfully disfigured by some process. To the amazement of all present, in the middle of the operation the patient calmly repeated the words said by the surgeon. Evidently she was hardly anesthetised (general narcosis). The same woman attracted attention to herself by the insensitiveness shown during the daily dressings of the operated area. Obviously the intense desire to be free of the disfigurement, probably connected with the sexual emotions, made her insensitive to the trauma of the operation under the influence of the hope and faith in its success. When after the operation, especially at first, the crude and comical artificial nose bitterly, cruelly disillusioned her, the same emotion made her now, on the contrary, very sensitive to every manipulation no matter how carefully performed.

Such cases are not rare in common life nor in history. As their basis one must always consider either, in the strong healthy subject, a complex of intense emotion and overpowering cortical associations under the influence of a dominant negative induction for the rest of the cerebral hemispheres, or, with the weak nervous system, the above described hysterical mechanism.

CHAPTER LIII

REPLY OF A PHYSIOLOGIST TO PSYCHOLOGISTS

(From the *Psychological Review*, Vol. 39, No. 2, March, 1932.)

COMPARATIVE POSITION OF PHYSIOLOGIST AND PSYCHOLOGIST—DISCUSSION OF PSYCHOLOGICAL CONSIDERATION OF CONDITIONED REFLEX—DELAYED REFLEX EXTINCTION—CONCRETE FACTS NEGLECTED IN THE PSYCHOLOGICAL CRITICISM—LASHLEY'S CRITICISM—CONCEPT OF REFLEX—DETERMINISM AND STRUCTURE—EXTIRPATION—EXCITATION AND INHIBITION IN THE CORTEX, ANALYSIS AND SYNTHESIS—LASHLEY'S CRITICISM OF THE REFLEX THEORY—SOLUTION OF MAZE PROBLEMS, COMPLEXITY OF NERVOUS STRUCTURE—LOCALISATION AND LASHLEY'S VIEWS—NECESSITY OF HYPOTHESIS—PAVLOV'S POSITION CONCERNING THEORY—GESTALT VIEWS AND CONDITIONED REFLEX CONCEPTS—FREE WILL.

THE article by Edwin R. Guthrie, "Conditioning as a Principle of Learning," * provides, it seems to me, special interest from its cardinal tendency, altogether justified to my mind, of ascribing phenomena designated as psychological activity to physiological facts, *i.e.,* of uniting or identifying the physiological with the psychological, the subjective with the objective, which I am convinced comprises the most important present-day scientific undertaking. The author treats the principle of learning in a general way, giving the characteristics of that process in an enumeration of its fundamental features, while he makes use of the material of psychologists, or of our physiological facts obtained with the method of conditioned reflexes with animals, without distinction. So far psychologist and physiologist proceed side by side. But beyond this point sharp differences arise between us. The psychologist takes conditioning as the principle of learning, and accepting this principle as not subject to further analysis, not requiring ultimate investigation, he endeavours to apply it to everything and to explain all the individual features of learning as one and the same process. For this purpose he takes a single physiological fact and in a decisive way gives it a specific meaning in the interpretation of certain concrete facts of the learning process and does not seek an actual confirmation of that meaning. From this, the physiologist is inclined to think that the psychologist, recently split off from the philosopher, has not yet altogether renounced partiality toward the philosophical method of deduction from pure logical work, without verifying every step of thought through agreement with actual fact. The physiologist proceeds in quite the opposite way. At every phase of his investigation he endeavours to analyse the phenomena individually and in connexion

* *Psychological Review*, Vol. 37, No. 5, 1930.

with facts, determining as much as is possible of the conditions for their existence, not trusting to mere deduction or to a single hypothesis. And this I shall prove in regard to several points, in which the author opposes me.

Conditioning, association by contiguity in time, conditioned reflexes, even if they serve as the factual point of departure of our investigations, are none the less subject to further analysis. We have before us an important question: What elementary properties of brain-mass form the basis of this fact? We have not yet reached a final solution of this question, but significant data are afforded by the following experiments. With our experimental animal, the dog, if the external agent which we wish to use as conditioned stimulus is applied after the beginning of the unconditioned stimulus, the conditioned reflex occurs (according to the latest and most exact experiments of Dr. N. V. Vinogradov), but is insignificant and temporary, disappearing in every case if the period of procedure be continued. A durable and lasting conditioned reflex, as we have long known, is obtained only when the external agent invariably precedes the unconditioned reflex. Thus the first procedure possesses a double effect: at first, temporarily, it assists in the formation of the conditioned reflex, and then destroys it. This latter action of the unconditioned stimulus comes out clearly in the following type of experiment. A conditioned stimulus well elaborated by means of the second (the usual) procedure,—if afterwards it be systematically applied after the beginning of the unconditioned (or becomes submerged by the unconditioned, according to our usual laboratory terminology), particularly if it belong to the category of weak conditioned stimuli—gradually loses all positive action and finally is even converted into an inhibiting stimulus. Evidently in this case the mechanism of negative induction (in our old terminology called *mechanism of external inhibition*) gradually prevails; *i.e.,* the cell excited by the conditioned stimulus is inhibited or comes to an inhibited state with repeated concentration on the part of the unconditioned stimulus—and the conditioned stimulus in this way meets in its cell a permanent state of inhibition. But this brings out the fact that the conditioning agent becomes inhibitory, that is, on being applied alone it now calls forth in its own cortical cell not an excitatory but an inhibitory process. Consequently during the usual process of formation of a stable conditioned reflex, the passage of a wave of excitation from the corresponding cortical cell to the centre of concentration of the unconditioned stimulus is exactly the fundamental condition which fixes the path fròm one point to another—more or less of a permanent joining together of the two nervous centres.

Let us pass now to other features of conditioned activity, where the

author, instead of our diversified analysis of facts, offers his own characteristic interpretation of the phenomena which take place. The delayed or postponed conditioned effect, according to our experiments, is based on special inhibition of early phases of the conditioned stimulus, since they do not fit in closely with the time of appearance of the unconditioned stimulus. The author for some reason asserts that we attribute this to "mysterious latencies" in the nervous system, and he gives his own explanation of the facts. He assumes that when for example the sound of a bell is presented as a conditioned stimulus, the animal responds with a reaction of "getting set to listen," a complex motor act, and the centripetal impulses in that act are, strictly, the true stimulators of the conditioned effect—in our case of the conditioned food reflex, the salivary secretion.

According to the author, "when the salivary glands begin to secrete, the accompanying stimuli are not furnished by the bell but by these responses to the bell. The direct response to the bell is probably over in a small fraction of a second." And further he says, "the apparent separation in time of a conditioning stimulus and its response is then quite possibly an illusion." The author even says that "Pavlov tends to forget," in his explanation of the delay, the existence of the abovementioned centripetal impulses from the motor apparatus. On page 360 of my book, *Conditioned Reflexes, An Investigation of the Physiological Activity of the Cerebral Cortex,** one can see that I not only take into account the centripetal impulses from skeletal musculature, but also consider as more than likely their existence in all tissues, to say nothing of individual organs. To my mind the whole organism with all its component parts can make itself known to the cerebral hemispheres. This shows that the point is not overlooked by me, but that actualities provide not the slightest ground for accepting the fact in the way it strikes the author.

First of all, if we grant with the author that not the bell, but the centripetal flow of impulses from the motor act of listening is the true stimulus for the conditioned effect, why does that effect, in the case of delayed reflexes, nevertheless come out, not at once, but after an interval—and, furthermore, in accordance with the length of the interval between the beginning of the stimulus and the beginning of the unconditioned reflex? For, when the unconditioned stimulus is delayed for a very short time (only a few seconds) after the beginning of the conditioned, the effect, brought about according to the author by centripetal impulses from the motor act of listening, appears as soon as two or three seconds. Where then is the explanation of the length of the delay? And how, when the conditioned stimuli precede the uncondi-

* Oxford Press, London, 1927.

tioned by several minutes, do the stimuli of the author, the centripetal impulses of motion, act after the lapse of minutes?

But as a matter of fact there is absolutely no ground for accepting a continuous action of the stimuli of which the author speaks. The listening response as a general orienting or investigating reflex, as I have termed it, appears with every new set of vibrations which habitually play upon the animal, and usually remains in existence only for the short period of the first application of the new recurring stimuli. Upon the formation of a conditioned reflex with a more or less short interval between conditioned and unconditioned stimuli, it is quickly replaced by the special motor reflex peculiar to the given unconditioned stimulus. And further, only the conditioned motor effect is permanently to be had, free from all trace of an orienting reaction. And thereupon the conditioned stimulus appears as a pure substitute for the unconditioned stimulus. In the case of a conditioned alimentary reflex the animal may lick the electric lamp, or appear to take the air into its mouth, or to eat the sound—that is, licking his lips and making the noise of chewing with his teeth as though it were a matter of having the food itself. The same thing occurs in the delayed reflex which is worked out. The animal remains completely indifferent and quiet in the first period of action of the conditioned stimulus; or even (as is not seldom the case) immediately upon the beginning of that stimulus, he drops into a drowsy and sometimes abruptly into a sleeping state, with relaxation of the musculature and snoring. This, on entering the second period of the conditioned stimulus, just a little before the addition of the unconditioned stimulus, is replaced (sometimes with a start) by a clearly suitable conditioned motor reaction. In both cases it is only during the general somnolence of the animal in the course of the experiment and occasionally at the first moment of stimulation that the orientation reaction appears.

And, finally, on analysis the delayed reaction actually proves to be the result of interference of a special inhibition which is by itself well known to us, and is studied in detail in many cases of its appearance;—but this is not a "mysterious latency." The meaning of all this is clear. Although prolonged for a significant length of time, the conditioned stimulus remains one and the same; but for the central nervous system (and it is especially necessary to think of the cerebral hemispheres) it is distinctly different in different periods of its course. This comes out particularly clearly with olfactory stimuli, which we sense at first very keenly, and then quickly as weaker and weaker, even if they remain objectively constant. Obviously the state of the stimulated cortical cell under the influence of an external stimulus undergoes successive changes and in the case of delayed reflexes only the state of the cell near in time

to the addition of the unconditioned reflex acts as a signal for the conditioned stimulus. This is exactly the case when, from different intensities of one and the same external stimulus, we can form different conditioned stimuli—now positive, now negative, now linked with different unconditioned stimuli. The analysed fact of delay is an obviously interesting case of special adaptation, in order that the conditioned reflex might not occur prematurely, so that energy beyond the necessary measure is not uselessly expended. That this explanation corresponds to reality is proved by facts. First of all it is clear from the process of formation of the delayed reflex. If the conditioned reflex be formed first with the short interval of a few seconds between the beginning of the conditioned and of the unconditioned stimuli, and then suddenly that interval be increased to a few minutes, then the conditioned effect, which was earlier quickly evoked, gradually and rapidly utterly vanishes. And then, on continuing the experiment, there appears for a considerable lapse of time a period of absence of all conditioned effects. Only then does the conditioned reflex appear anew, at first just at the moment preceding the addition of the unconditioned stimulus. Thence it grows gradually and recedes somewhat from the time of appearance of the unconditioned stimulus.

That the first period of the delayed reflex is indeed a period of inhibition is proved by a series of facts. In the first place, inhibition of the delayed reflex can easily be summated. And, again, from the delayed reflex one can observe successive inhibition. And, finally, the drowsy and sleepy state which comes out in some animals in the first part of the delayed reflex is a striking expression of the state of inhibition.

The next phenomenon, extinction of the conditioned reflex, the author also discusses without paying any attention to the details of the facts of our investigation, having in view again the very same factor conjectured by him, but no more exactly defined than before. And along with it he now ascribes to me, besides the previously mentioned "tendency to forget" a concealing of something from myself.

First of all the author takes a stand against us by saying that it is not the brevity of the interval between repetitions of the non-reinforced conditioned reflexes that contributes to extinction of these reflexes, but the number of repetitions. But this is absolutely untrue. An unreinforced conditioned reflex without any repetitions, but simply prolonged from 3 to 6 minutes, ends in every case in extinction, to an absolute zero—as we say, in an uninterrupted extinction, in contrast to an intermittent one. And furthermore, the author arbitrarily supposes that extinction is not a constant fact, but an exception to the rule of frequency. Again an absolutely incorrect statement. Extinction is one of the constant facts of the physiology of conditioned reflexes. Having

accepted both these things in spite of reality, the author, so to speak, clears the field of action for himself and imagines some different kind of agents—no better determined—which in addition to the fundamental unconditioned stimulus take part in the formation of the conditioned effect. Probably here also movements of the animal are assumed, because mention is made of continuous and of various movements of the animal during the experiment. Thus, according to the author, the sum of the agents determining the conditioned reflex continually fluctuates, appearing now greater, now less. When these agents become fewer and the conditioned reflex is absent or becomes diminished, the rest of the agents, also unknown, become inhibitory as well, or, what is practically the same, they become stimulators of other responses.

The breaking up of extinction by extraneous stimuli the author explains by saying that those stimuli "disorganise posture and orientation" which appear as inhibitors of the conditioned reflex at this stage of extinction and thus temporarily restore the reflex which was becoming extinguished.

The author does not deem it necessary to inform us, even hypothetically, just what sort of stimuli support the conditioned reflex together with the unconditioned, and what other sort here present serve as inhibitors of that effect. When the author in his own way explains the breaking up of extinction by extraneous stimuli, why does he not state in what way the extraneous stimuli, which sweep away the action of the agents that inhibit the conditioned effect, fail to remove also the action of those which facilitate the conditioned response? For they are other stimuli but not the latter!

And so there is introduced by the author, without any factual confirmation of their actual meaning, a number of unknown stimulating agents utterly undetermined in a more exact way.

We must conclude that the author understands them to be just these same kinesthetic stimuli, but arising from different muscles. Of course there are many skeletal muscles, and from them arise during their action an almost countless number of combinations, and from all of them special centripetal impulses are constantly being sent to the central nervous system. But, in the first place, the most important part of these impulses proceed to the lower divisions of the brain, and, secondly, under usual circumstances they absolutely do not make themselves known to the cerebral hemispheres but serve only for the self-regulation and greater precision of movements, such as, for example, the continuously occurring cardiac and respiratory movements.

Under the conditions of our experiments only such movements are reckoned with as exert an influence over our conditioned reflexes—only those movements which form special motor reflexes, the chief and

almost the only one of which is the orienting reflex to the vibrations of the immediate environment, and sometimes also defence against some chance nocuous influence on the animal during his movements on the experimental stand—a blow from something, some sort of pinch, etc.

If the centripetal impulses, such as the author assumes to arise from all movements which we execute, really proceeded to any considerable extent into the cerebral hemispheres, then by their very number they would provide a tremendous hindrance to a relationship of the cortex with the external world, almost excluding it from its principal rôle. Can it be that, when we talk, read, write, and in general think, our movements, which arise inevitably as we do so, disturb us to such an extent? Can it be that all this is ideally performed only during our periods of absolute immobility?

The constant fact of extinction is not due to the play of chance movements of the animal which are reflected in the work of the hemispheres, but it is the manifestation, according to law, of the most important properties of the cortical cells, as the most reactive of all cells of the organism, when they remain at work for a greater or less period of time —even if generally a short one—without a satisfying accompaniment for the fundamental innate reflexes; for, the chief physiological rôle of excitation of these cells is to serve as signals in place of the special stimuli of the latter reflexes. As the most reactive cells, they quickly become fatigued from work and go on not to an inactive state but to inhibition, which probably not only assists in their rest but also hastens their recovery. But when they are accompanied by unconditioned stimuli, then these stimuli—as we have seen at the beginning of the article—at once, and so to speak by way of protection, inhibit them and thus contribute to their recovery.

That extinction is actually inhibition, is proved as well by its successive inhibitive effect on other positive conditioned reflexes as by the transition to drowsy and sleeping states, which is without doubt inhibition.

As to the two other points, where the author offers merely his own view in place of our explanation, I can be more summary. In regard to the fact of gradual intensification of the conditioned effect during the process of its formation, it is necessary to state that in this case it is the gradual removal of extraneous stimuli which disturbs the formation of the reflex, and not the opposite, namely, the author's view, which consists in attributing to these stimuli an ever-growing rôle in creating the conditions for the effect. During our first experiments often 50 to 100 or more repetitions of the procedure were required in order to develop a complete conditioned reflex, but now 10 to 20 times are sufficient, and often much fewer. Under the present technique of our experimen-

tation, during the first application of a new indifferent agent (the future conditioned stimulus) there results only an orienting reflex, the detection of the motor component of which in the great majority of cases rapidly diminishes to complete disappearance—so that there is here absolutely nothing out of which this ever-growing sum of determinations of the conditioned effect should form itself, as the author puts it. It is clear that the whole process consists in an ever-growing concentration of stimuli and then, perhaps, in gradually beating a path between connected centres in the central nervous system.

Finally, in regard to the independent acquisition of a conditioned effect from the stimuli in the neighbourhood, or near that to which the conditioned reflex is specifically formed, the author is again of a different mind from us. According to us, this is an irradiation of stimulation spreading over a definite part of the cortex. But the author, having taken for granted that for the conditioned stimulus there appears not merely a specific exciting agent but an accompanying orienting reflex, now explains the matter by saying that all the neighbouring agents receive their own activity thanks to one and the same orienting reflex. But this quite contradicts the facts. The neighbouring agents in the majority of cases give the conditioned effect directly, without any trace of orientation. But when the orienting reflex exists besides, it is just then (on the contrary) that the conditioned effect either is completely absent or appears very weak; it comes forth and grows only in proportion to the disappearance of the orienting reflex.

And so throughout his article the author remains true to himself, to his own habits of deduction. Making incorrect use of one physiological principle—the fact of conditioning—all the details of conditioned nervous activity which he utilizes for his theme of learning he derives therefrom immediately and constantly, while a whole mass of concrete facts remain without the slightest attention on his part.

II

It seems to me that the second article, "Basic Neural Mechanisms in Behaviour," * to which I turn now, bears to a considerable extent the same character in the development of its theme as the first. This article presents a paper read by K. S. Lashley at the last International Congress of Psychology in the United States in 1929. Granting that its material is almost exclusively physiological, yet the author's method of treating it is quite that of the preceding article. The material is sacrificed to the fundamental preconceived tendency to demonstrate that the reflex theory "is now becoming an obstacle rather than a help to progress" in the study of cerebral function, and that, of more strength

* K. S. Lashley, *Psychol. Rev.*, Vol. 37, Nos. 1-24, 1930.

and significance than the reflex theory, is for example the statement of C. Spearman, that "intelligence is a function of some ur differentiated nervous energy,"—an analogy to the tissue of sponges or hydroids, which, being crushed and sifted through bolting cloth, afterwards when settled out or centrifuged down, forms itself anew into a mature specimen with characteristic structure.

First of all I must state in a general and all-inclusive way, without going into detail for the present, that such a merciless judgment of the reflex theory divorces itself from actual facts absolutely. One may even say, it is somewhat strange that it does not desire to call attention to them. Is it possible that the author ventures to intimate that my thirty years' work, continuing still with success, with many collaborators, proceeding under the guiding influence of the conception of reflexes, presents only a drag on the interpretation of cerebral function? No; no one has the right to say that. We have established a series of important principles of the normal activity of the higher divisions of the brain, defined a series of conditions both of its waking and of its sleeping states; we have made clear the mechanism of normal sleep and hypnosis; we have produced experimentally pathological conditions of this neural level, and found means to bring it back to the normal. The activity of this level, as we have already learned, found and is finding in itself quite a number of analogies with the phenomena of our subjective world, as is brought out in statements not infrequently made by neuropsychiatrists, educators, experimental psychologists, and in the assertions of academic psychologists.

Now, before the physiology of this neural level lies a vast horizon, with questions jutting out, absolutely definite problems for further experimentation, in place of very nearly a blind alley, in which this physiology unquestionably found itself a few decades back. And all this thanks to the use of experiments made on this part of the brain under the concept of reflexes.

Of what does the concept of a reflex consist?

The theory of reflex activity finds its support in three fundamental principles of exact scientific investigation: in the first place, the principle of *determinism, i.e.,* an impulse, appropriate conditions, or a cause for every given action or effect; secondly, the principle of *analysis and synthesis, i.e.,* the initial decomposition of the whole into its parts or units, and then the gradual reconstruction of the whole from these units or elements; finally, in the third place, the principle of *structure, i.e.,* the distribution of the activity of force in space, the adaptation of function to structure. Therefore it is impossible that the death sentence for the reflex theory be taken otherwise than as a misunderstanding or bias.

We have before us living organisms, man included, producing a series

of activities, manifestations of force. And there is an immediate impression, hard to surmount, of some voluntary freedom of action, of some spontaneity. In the case of man, as an organism, this impression appeals to almost every one as obvious, and an assertion to the contrary seems absurd. Although Leukippus of Miletus* announced that there is no motion without cause and that everything arises out of necessity, is it not still asserted, even of animal organisms besides man, that spontaneously active forces exist in the organism? And in regard to man, do we not hear even now of freedom of the will, and is there not rooted in the mass of intellects the conviction that we possess something which is not subject to determinism? I have met constantly and am still meeting not a few educated and intelligent people who are in no way able to understand how it could ever be possible to learn all about the behaviour (for example) of a dog in a purely objective way,—*i.e.*, by merely comparing the stimuli acting upon the animal with the reactions to them, and therefore not taking into consideration their subjective world, which is supposed to exist analogous to our own. Of course we refer here not to the temporary, let alone immense, difficulty in experimentation, but to an absolute impossibility of complete determinism as a principle. It stands to reason that this same view is held, only with far greater conviction, in regard to man. It would not be a great error on my part if I held it probable that this conviction persists also among psychologists, masked by assertions of the *unique features of psychic phenomena,* under which, disguised by various scientifically decent synonyms, is felt all this dualism and animism immediately shared by a mass of thinking, not to say religiously minded, people.

Now, just at its very first appearance, the theory of reflexes constantly increases without cessation the number of phenomena in the organism which are connected with the conditions that determine them; *i.e.,* this theory makes more and more clear the integrated activity in the organism. How can it possibly be an obstacle to the progress of studying the organism in general and the cerebral functions in particular?

Further, the organism consists of a great mass of separate parts and of billions of cellular elements, providing a corresponding quantity of separate phenomena, but closely interwoven among themselves and organised for the integrated work of the organism. The theory of reflexes divides this general activity of the organism into separate activities, connecting them with internal as well as external influences, and then unites them anew, one to another, which brings us to a more and more clear understanding of the total activity of the organism, as well as of the interaction of the organism with surrounding conditions. How has the

* I take this information from Professor Kannabich's book on the *History of Psychiatry*.

reflex theory been and at the present time can it be superfluous or irrelevant, since there is still neither sufficient knowledge of the connexions of the separate parts of the organism, nor a more complete interpretation of all the relationships of the organism with surrounding conditions? But all internal as well as external relationships in higher organisms are above all accomplished by means of the nervous system.

Finally, if a chemist, analysing and synthesising, for the ultimate understanding of the work of the molecule, has to use his own imagination about its invisible structure, if a physicist, similarly analysing and synthesising, for a clear idea of the work of the atom, also pictures to himself the structure of the atom—how is it possible to repudiate the structure of visible masses and take for granted some kind of contradiction between structure and function? The function of the connexions, of internal as well as external relationships in the organism, is realised in the nervous system, which represents a visible apparatus. In that apparatus of course spring up the dynamic phenomena, which must be timed exactly to the finest detail of the apparatus.

The theory of reflexes began to investigate the activity of this apparatus with the definition of its special function, naturally of its more simple, grosser parts, and determined the general tendency of the dynamic phenomena arising in it. Here is the general and basic scheme of a reflex: receptor apparatus, afferent nerve, central station (centres), and efferent nerve with tissue through which it operates. Then came and still comes a detailed elaboration of these parts. Of course a most complex and immense work has been in store and is yet in store for the central nervous stations, and in the parts of the central stations for its grey matter, and in the grey matter for the cortex of the cerebral hemispheres. This work concerns both the visible structure itself and the dynamic phenomena arising in it, while all the time of course the necessary tie between structure and function is not lost sight of. Owing to the difference of method in the study of structure and function, the investigation is naturally divided for the greater part between the histologist and the physiologist. There is not a histological neuropathologist of course who would venture to say that our knowledge of the structure of the nervous system and the special higher division of the central nervous system has been brought to an end; on the contrary he will admit that the structure of these parts still remains in a state of high confusion and darkness. Has not the cytoarchitectonics of the cortex of the hemispheres, though readily scrutinised, been shown only recently to be extremely complex and diverse? And has not all this manifold variety in the organisation of the different parts of the cortex been hitherto without definite dynamic meaning? If it is possible for the histologist to analyse the structure as yet only to a small extent, how can the physiologist ex-

pect to trace fully the action of the functional phenomena along this inconceivable network? The physiologist, keeping to the reflex scheme, never imagined an investigation of the central stations worked out in detail even to a limited extent in the simplest structure of these centres, but he constantly held to and was guided by the fundamental representation of the fact of transmission, the transfer of a dynamic process from the afferent to the efferent path. As regards the higher centres, besides the possibility of adapting function to the details of structure, he concentrates his attention and his work, for the present from sheer necessity, chiefly on the dynamics, on the general functional properties of the brain. This has been done and is being done till very recently, mainly by the schools of Sherrington, Verworn, and Magnus, and by other individual authors, on the lower levels of the central nervous system; but on the highest levels it is being done for the most part and in the most systematic way just now by me and my co-workers under the guidance of the conditioned reflex variety of the general reflex theory.

In regard to the cortex of the hemispheres, at the beginning of the notable epoch of the 'seventies of the last century the first indisputable data were obtained about the detailed connexions between its function and its structure. Though the existence of special motor tracts in the cortex was confirmed and reconfirmed by all further investigators, the very exact and limited localisation of the organs of sense in the cortex, as originally described, soon met with objections on the part of physiologists as well as neurologists. This to some degree shook the doctrine of localisation in the cortex. This uncertain state of affairs continued for a long time, owing to the fact that the physiologist did not have his own purely physiological characterisation of the normal action of the cortex; and the treatment by psychological conceptions, at a time when psychology had not yet arrived at a natural and universally accepted systematisation of its phenomena, was of course unable to assist in further experimentation on the question of localisation. The situation changed radically when, thanks to the doctrine of conditioned reflexes, the physiologist at length received the means of viewing with his own eyes the special, though purely physiological, work of the hemispheres and thus was able to distinguish clearly the physiological action of the cortex from the action of adjacent subcortical parts and in general of the lower levels of the brain, in the form of conditioned and unconditioned reflexes. Then all the earlier facts, which had however been broken into, could be brought back into a distinct and strict order, and a fundamental principle of the structure of the hemispheres came out clearly. From the 'seventies on, the special tracts in the cortex which had been pointed out as centres for the chief external receptors remained the locations of higher synthesis and analysis of corresponding stimuli, but in addition to them repre-

sentatives of these receptors were acknowledged to be scattered, perhaps throughout the whole cortex, certainly through the greater part of it, but available merely for the more simple and quite elemental synthesis and analyses. A dog without occipital lobes was unable to discriminate one object from another but did discriminate degrees of illumination and simplified forms. A dog without temporal lobes did not discriminate complex sounds such as his own name, etc., but did discriminate exactly separate sounds, for example one tone from another. What striking demonstrations of the fundamental significance of specialised structure!

Of interest as a more specific indication of the functional significance of the structural characteristics of special tracts is the following experiment of M. I. Elliason, which was reported in my book, *Conditioned Reflexes, an Investigation of the Physiological Activity of the Cerebral Cortex.* From three tones of a harmonium, two extreme and one intermediate, covering a range of over three and one-half octaves, given simultaneously, a complex conditioned food stimulus was provided, which yielded a definite amount of saliva as an index of the intensity of the food reflex. When further tested, the component tones of the complex also separately produced salivary responses, but less than the whole complex, and intermediate tones between these also produced salivary responses, but to a still slighter degree. Then the anterior parts of the temporal lobes (*Gyr. Sylviaticus et Ectosylvius*) on both sides, with the anterior part of the *Gyr. Compositus* posterior were excised. The following occurred. When all conditioned reflexes to stimuli from the various analysers were restored after the operation—such as the conditioned reflex to the chord (this even before some others)—the reflexes to the component tones of the chord were tested anew. The high tone, as well as the intermediate tone next to it, lost its action. But the middle and the low tones retained theirs; the low tone even increased its action, which now became equal to the effect of the whole chord. But when the high tone alone began to be accompanied by food, then it quickly (from the fourth trial on) became again a conditioned food stimulus and acquired a significant effect, not a lesser but a greater one than before. From this experiment one can draw certain exact conclusions: in the first place, that in different centres of the special auditory field of the cortex are represented individual elements of the receptive auditory apparatus; second, that complex stimuli use only this area; and, thirdly, that representatives of the same elements of the auditory apparatus scattered through a great part of the brain have no positive rôle at all in these complex stimuli.

When it is seen, as I saw it with conditioned reflexes in hand, that a dog with most of the posterior part of both hemispheres removed orients himself with a high degree of exactness to skin and olfactory receptors,

losing only complex visual and auditory relationships with his surroundings, *i.e.*, not differentiating complex visual and auditory stimuli; that a dog without the upper halves of both hemispheres, retaining fully a complex auditory relationship with his surroundings, loses only—with a striking isolation—the ability to orient himself with regard to hard objects met in the environment; and that, finally, a dog lacking almost all the interior halves of both hemispheres seems to be completely incapacitated, *i.e.*, to be practically deprived of normal locomotion, of normal use of his skeletal movements, but nevertheless by another indicator, namely the salivary glands, there is evidence of complex nervous activity —when all this is seen, is it possible not to be impressed with the paramount significance of the bare structure of the cerebral hemispheres in the fundamental problem of a proper orientation of the organism in its environment—equilibrating with it? How then can we doubt the further significance of the more detailed features of the structure?

If one were to take the exact standpoint of our author, described further on in detail, he would have to bid the brain histologists throw away their work as unnecessary, useless. Who would not shrink from such a conclusion? Otherwise, all the details of structure which are revealed must sooner or later find their own functional significance. And, therefore, along with further histological studies of cortical substance, carried on even more searchingly, it is necessary to pursue pure, rigorous physiological investigations of the activity of the hemispheres and of the adjacent parts of the brain, so that gradually one may be connected with the other, structure with function.

And this is what is accomplished by the theory of conditioned reflexes.

Long ago and firmly, physiology announced a constant connexion of definite internal and external stimuli with the explicit activities of the organism in the form of reflexes. The theory of conditioned reflexes indisputably confirmed in physiology the fact of temporary connexion between stimuli of all kinds, and not merely the definite ones, external as well as internal, with definite units of activity of the organism, *i.e.*, along with the conduction of nervous processes to the higher centres, it also stated exactly the phenomena of their connexion and disconnexion. By this addition, of course, no essential change in the conception of a reflex has come to pass. The connexion of a definite stimulus with a unit of activity of the organism remains, but without exception under conditions that are exactly defined. That is why this class of reflexes has been given by us the designation of "conditioned," to distinguish them from the reflexes which exist inborn; and these older ones are called "unconditioned." Thanks to this the investigation of conditioned reflexes rests on the same three principles of the reflex theory: the principles of determinism, of gradual and successive analysis and synthesis, and of

structure. For us, the effect is constantly linked with the cause, the whole is further and further divided into parts and then synthesised anew, and function remains connected with structure in so far of course as that is permitted by the data of modern anatomical investigation. Thus there is opened up, so to speak, an unlimited possibility of studying the functions of the higher divisions of the brain, *i.e.,* of the cerebral hemispheres, and of the adjacent subcortex with the most complicated fundamental unconditioned reflexes of the latter.

We successively study the fundamental properties of the cortical substance, define the essential action of the hemispheres, and clear up the connexions and interdependence of the hemispheres and the adjacent subcortex.

The fundamental processes of cortical activity are excitation and inhibition, their spread in the cortex in the form of irradiation and concentration, and their mutual induction. The special action of the hemispheres consists in an unceasing analysis and synthesis of stimuli entering (for the most part) from external surroundings as well as from within the organism, after which these impulses are directed to lower centres beginning with the adjacent subcortex and ending with the cells of the anterior horns of the spinal cord.

Thus all the action of the organism occurs under the influence of the cortex in a most exact and most delicate correlation or equilibration with the environment. On the other hand the adjacent subcortex sends a powerful stream of impulses from its centres to the cortex whereby the tonus of the latter is maintained. As the final result the centre of gravity of the examination of the higher divisions of the brain is now being transferred to the investigation of the functional phenomena of the hemispheres and adjacent subcortex.

As stated above, the fundamental work of the cortex consists in analysis and synthesis of impulses flowing into the cortex. The variety and number of these stimuli are countless, even in an animal like a dog. The most suitable formulation for expressing this number and variety of stimuli would be to say that for individual stimuli there appear all gradations in the states both of individual cortical cells and of their various combinations. By means of the cortex it is possible to elaborate special stimuli from all stages and varieties of the process of excitation as well as of inhibition, in individual cells as well as in their various combinations. Stimulation from different intensities of one and the same stimulus, the relationship of stimuli, etc., may serve as an example of the first, and as an example of the second, different conditioned stimuli which produce hypnosis.

These countless states of the cells not only take form under the influence of a stimulus that is going on, not only exist at the time of action

of the external stimulus, but remain also in the absence of these in the form of a system of different, fluctuating but more or less stable, degrees of excitation and inhibition. To give an illustration of this phenomenon: We apply daily for some time a series of positive conditioned stimuli of different intensity, and of negative stimuli, in one and the same sequence and with the same intervals between all of them—and we obtain a system of corresponding effects. If, then, during an experiment we repeat after each interval only one of these positive stimuli, then it reproduces just the same fluctuations of the effect that all the successive stimuli together produced in the previous experiments; *i.e.*, the same system present in the state of excitation and inhibition of the cortex will repeat itself.

Of course, it is not permissible to carry out at once any far-reaching correlation between dynamic phenomena and details of structure; but this correlation is by all means admissible, for the structure of the cortex is so variegated throughout its whole extent, and there is the fact, which we already know certainly, that only certain phases of synthesis and analysis of stimuli are admitted to one portion of the cortex and to none other. And this same point is decidedly confirmed by a further finding of ours. From a series of different auditory stimuli (a tone, noise of escaping air, beats of a metronome, bubbling, etc.), or from the mechanical stimulation of different parts of the skin, developed into conditioned stimuli, we can lead a single stimulus to produce an abnormal or pathological effect and in the meantime the others will remain quite normal. We arrive at this result not by a mechanical process but by a functional one—by bringing a given point of stimulation into a difficult position, or by means of excessive strength of stimulation, or by a severe conflict at that point between the processes of excitation and inhibition. But how can this be interpreted except that excessive functioning, brought about by us on the part of a given minute detail of the structure, had brought it to destruction, as though rough treatment with a very fine instrument had spoiled or destroyed it? How fine and highly specialised these details must be, if other auditory and mechanical stimuli remain completely preserved and untouched! Such isolated destruction could hardly be produced at any time by mechanical or chemical means. After this, one cannot doubt that if at present we sometimes do not see changes in the behaviour of the animal after mechanical destruction of the cortex, this is only due to the fact, which is self-evident, that we have not yet analysed the behaviour of the animal in all its elements, and that the number of these elements must be tremendous. And, therefore, a dropping out of some of them naturally escapes our attention.

I have let myself linger so long on our data for the purpose, in the first place, of making further use of them in the criticism of the experi-

ments and the conclusions drawn from them by Lashley, and, secondly, of showing once more how fruitful at the present time is the investigation of the cerebral hemispheres, based on the entire reflex theory with all its principles.

But what does Lashley bring up against the reflex theory? With what does he break it down? * First of all it is quite obvious that he conceives it in a peculiar way. Arbitrarily, not reckoning with physiology, he thinks of it all only in terms of structure, without a single word regarding its other principles. It is universally accepted that the notion of the reflex originated with Descartes. But what was known about the detailed structure of the central nervous system, especially in connexion with its activity, in the time of Descartes? For the physiologico-anatomical distinction between sensory and motor nerves was not made until the beginning of the 19th century. It is evident that for Descartes the idea of determinism alone formed the essence of the notion of a reflex and from it issued Descartes' conception of the animal organism as a machine. In this sense all later physiologists interpreted the reflex, tying the individual action of the organism up with the individual stimuli, at the same time gradually bringing to light the elements of nervous structure in the form of different afferent and efferent nerves and in the form of special paths and points (centres) of the central nervous system, until they finally gathered together the characteristic features of the functions of the latter system.

The chief actual grounds upon which Lashley's conclusion regarding the present harmfulness of the reflex theory is advocated, and the new mode of conceiving the mechanism of the brain is recommended, are drawn by the author from his own experimental material. This material consists mainly of experiments on white rats which learn the shortest path to the food compartment in a more or less complicated maze. According to the author's experiments, it was shown that the training is more difficult in almost the exact degree, the greater the destruction of the hemispheres in the first place; and aside from this, it is quite immaterial which parts of the hemispheres undergo destruction, *i.e.*, the result is determined solely by the mass of the hemispheres remaining intact. After some additional experiments, the author comes to the conclusion that "specific cortical areas, and association or projection tracts, seem unessential to the performance of such functions which rather depend upon the total mass of normal tissue." Thus there is asserted to

* Simultaneously with the above-mentioned paper read at the Congress of Psychology appeared the monograph entitled *Brain Mechanism and the Intelligence* by K. S. Lashley, reporting more fully the author's own experimental material; I shall therefore, in my further statements, refer to the address and monograph without making any distinction between them, drawing on facts, conclusions, and discussions therein.

exist an original but really quite inconceivable situation that the more complex activities of the apparatus are performed without the mediation of the special parts and chief connexions—in other words, that the whole apparatus works somehow independently of its constituent parts.

And so the main question is: Why does the solution of the maze-problem, which is performed regularly more slowly, depend only on the *extent* of destruction of the hemispheres, regardless of the relationship of the *location* of destruction? And here one regrets that the author did not keep in mind the reflex theory with its first principle of determinism. Had he done so, the first question which he would have had to raise regarding the method of his experiments would have been the following: By what means can the general maze-problem be solved by a rat? It surely cannot be solved without some directing stimulus, without some kind of cue. For if we accept the opposite view, notwithstanding its difficulties, then we would certainly have to show that the task can be actually carried out without any stimuli at all, *i.e.*, it would have been necessary to destroy all the rat's receptors at once. But who has done this and how can it be done? But if, as is natural to suppose, for the solution of the problem, signals—certain stimuli—are essential, then destruction of individual receptors or of some of their combinations is obviously insufficient. Perhaps all or almost all the receptors serve in the response, with a substitution of one for another separately or in some combinations. And for the rat, under the recognised conditions of its life, this is certainly the case. It is not difficult to picture to oneself that in solving the maze-problem the rat can make use of olfactory, and auditory, and visual, and tactile, and kinesthetic stimuli. And since the special centres of these receptors are situated in different places in the hemispheres, and representatives of their single elements very likely exist scattered throughout the whole mass of the hemispheres, there always remains the possibility of their solving the problem, however much of the mass of the hemispheres we have removed,—and the solution is naturally all the more difficult, the less there remains of unimpaired cortical tissue. But if one assumes that in the case under consideration the rat uses only a single receptor, or only a few of them, then it is first necessary to demonstrate this by special experiments which leave no doubt, *i.e.*, by letting each sort act separately, or in some combinations, and excluding the others. But no such experiments have been made, either by the author or anyone else, so far as I know.

It appears indeed strange that the author pays no attention whatsoever to all these possibilities and does not put to himself the question: What then appears to be the basis for the rat's action in overcoming the mechanical obstacles; what stimuli, what cues serve for the corresponding movements? He limits himself merely to experiments which

involve the destruction of individual receptors separately and in certain combinations, which do not wipe out the habit, and he ends his analysis of the fact of the habit with the statement: "The available evidence seems to justify the conclusion that the most important features of the maze habit are a generalisation of direction from the specific turns of the maze and the development of some central organisation by which the sense of general direction can be maintained in spite of great variations of posture and of specific direction in running." Indeed—one can say—some kind of bodiless reaction.

As additional experiments by the author relating to the reactions in the maze, various incisions into, under, and across, were made both in the hemispheres and in the spinal cord, for the purpose of excluding altogether the association and projection tracts in the hemispheres and the paths leading to the cord. But we must point out that all these, as physiologists well know, are only rough, approximate methods, and in no way decisive—the more so, the more complicated the structure. This is much more true in respect to the gross and simple peripheral nervous system. Physiologists well know how difficult it is completely to isolate organs from the nervous connexions with the whole body, and often only total excision of an organ from the body gives absolute assurance in this respect. Physiologists are quite familiar with the various crossings and loops, etc., in the peripheral nervous system. Let us recall for example in the case of the antidromic sensory fibres (sensation) in the spinal roots and the innervation of a single muscle by fibres from different roots. Then how many times more diverse and more delicate must this, so to speak, mechanical immunity be in the central nervous system under the tremendous elaboration of its existing connexions. It seems to me that up to the present, particularly in the physiology of the nervous system, this highly important principle has received insufficient recognition and has not even been formulated clearly and constantly. For the system of the organism developed itself in the midst of all its surrounding conditions: thermal, electrical, bacterial, etc., including also mechanical conditions; and it had to bring all these into equilibrium, to become adapted to them, possibly to anticipate or restrict their action when destructive to itself. In the nervous system and especially in its most complex central part, which rules the whole organism, and unites all the special activities of the organism, this principle of mechanical self-defence, the principle of mechanical immunity, had to arrive at absolute perfection, which it has actually done in the majority of cases. As we are unable at present to claim complete knowledge of all the connexions in the central nervous system, all our experiments with incisions, sections, etc., practically appear in many cases to be merely negative, *i.e.*, we do not accomplish the final aim of severing them because the mechanism appears

more complicated, so to speak, more highly self-regulatory, than we had pictured it. And therefore to draw a decisive and far-reaching conclusion on the basis of such experiments is always risky.

In connexion with our first question, I shall turn to the problem of the comparative complexity of habits, which the author was investigating. I shall do this chiefly for the sake of evaluating the methods which he uses. The author finds that the maze habit is more complicated than the habit of discriminating different intensities of illumination. But how is this demonstrated? In fact it is shown that, on the contrary, a habit in the most difficult of the mazes was formed in 19 trials, while the brightness habit was formed in 135 experiments, *i.e.,* seven times less easily. If a comparison be made with the simplest of the three mazes used by the author, then the difference in difficulty amounts to about 30 times. In spite of this the author comes to the conclusion that the maze habit is more complex. This is accomplished by means of various explanations, but, in order to carry conviction, he would somehow have to determine exactly, quantitatively, the significance of the several factors suggested in his explanation, showing why all of them taken together not only obscure the actual difference but even transform the result into its opposite.

With such a state of affairs, I would not venture to say what is complex and what simple. Let us come to the point. For the movements of the animal in the maze and in the box with different illumination we take into account only the turning to right or left, not every act of locomotion. In both problems cues or special stimuli are requisite for the turns. They exist in one and the other case. But beyond this a difference appears. In the maze there are several turns, in the box one. Therefore in this respect the maze is more difficult. But there is still another difference. In the maze the signs for turning are distinguished almost exclusively by their *quality.* For example, contact with the openings of the partition during turning occurs now on the right side, now on the left side of the body; in making the turns the muscles work alternately on the right and on the left. And this applies also to visual and auditory signals. In the box it is a matter of *quantitative* difference. These differences must somehow be evaluated. And, of course, the life habits of the rat must interfere, *i.e.,* the more or less early familiarity with one or another problem—as the author rightly points out. But it is also impossible to disregard the fact that in a very complex maze the problem is greatly facilitated by definite rhythm, by a regular alternation of turns now to right, now to left. On the other hand, in the habit of discriminating intensities of illumination we must take into serious consideration the fact that the formation of this habit arises under the in-

fluence of two impulses: food and nocuous stimuli (pain), whereas in the maze only food fixes the habit. And this of course complicates the conditions of training. Still another question: Do two impulses favor or impede the formation of a habit? Moreover, we pointed out above that the formation of a system of effects is a very easy and persistent thing in nervous activity. Thus in both methods, in the maze and in the box, we have as data different existing conditions, so that an exact comparison of the difficulties of the problem becomes almost impossible. All this, together with the uncertainty of the cues in the maze, as we noted above, make the entire method of the author to a considerable extent problematical.

That our author is more inclined to theorise—to draw conclusions—than to make refinements in his own various experiments (which is a fundamental requirement in biological experimentation), can be seen from the following two investigations of his, in connexion with these experiments.* In one of these papers he investigates the visual habit formed to a given intensity of illumination. Having destroyed in a rat the occipital third of the hemispheres, he finds that the formation of the visual habit does not lessen the speed in comparison with the normal animal. But if that habit be formed in normal animals and thereafter the visual part of the hemispheres be removed, then the habit drops out and has to be formed anew. From this he draws the rather daring conclusion, which is sufficiently hard to conceive, that the process of training in general is independent of the site of injury, while the mnemonic trace or engram has definite localisation. But the matter is far more simple. In the occipital lobes, as we know, lies the special visual area, to which first of all come the stimuli from the eyes and where they enter into functional connexions with one another for the formation of complex visual excitations, and also immediately into conditioned connexions with the various activities of the body.

But since the visual fibres extend much further than just within the occipital lobes, probably throughout the whole mass of the hemispheres, then outside these special lobes they serve for the formation of conditioned connexions with the various activities of the body, in the form of more or less elementary visual stimuli only. And if Lashley should form a habit not to the intensity of light but to an individual object, then the habit would disappear after removal of the occipital lobes and would not be formed anew. And thus the difference between the place of formation of the habit and the place of the mnemonic path would not appear.

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* K. S. Lashley, "The Relation between Cerebral Mass, Learning, and Retention," *Jour. Comp. Neurol.*, 1926, 41, No. 1. "The Retention of Motor Habits After Destruction of the So-called Motor Areas in Primates," *Arch. Neur. and Psychiat.*, No. 12, pp. 249-276, 1924.

In another research Lashley makes experiments on the motor tract in the cortex in monkeys. The motor habit does not disappear after removal of that tract. From this he draws the conclusion that the tract has no relation to that special habit. But in the first place, in his three experiments, he does not remove the tract entirely; perhaps the parts that remain are still sufficient for a mechanical habit of this given complexity. He sets this probability aside, not by experiment but only by argument. And again, besides the highly specialised motor area determined by electrical stimulation, there is perhaps a less specialised and more diffuse area. Accordingly, on these two grounds a more drastic complication of the mechanical problems is necessary. Finally, why has not the author blinded his animals?—for there is no doubt that in the manifestation of the habit vision has played a rôle, and stimulation in the lower motor apparatus might be effective through the visual cortical fibres as well. We meet striking examples of this in ataxic patients in cases of degeneration of the cord (*tabes dorsalis*). The ataxic subject can stand on one leg with his eyes open, but falls if the eyes are closed. Consequently in the first situation he replaces kinesthetic paths by visual. Again a hiatus in the necessary further experimentation under the influence of his favourite attitude toward specific localisation.

Let us turn now to other experiments and arguments of the author, aimed directly against the reflex theory. As regards the analysis of different adequate stimuli, the author says that there is surely no restriction to certain specific receptor cells which invariably take part in the formation of a habit and its reproduction, and that this is most evident in pattern vision. But in the first place we must see objects, *i.e.,* we receive definite combined visual stimuli with the help of every part of the retina, but not from the entire retina en bloc. And the effect is carried to the projection of the retina in the cortex. This is the reason why there is no definite connexion between given receptor cells and a definite reaction. Only when we study an object in detail do we make temporary use of the *fovea centralis;* usually every part of the retina serves for a similar reaction to the given object. This principle applies also to the projection of the retina in the cortex. Second, as regards identity of response in the case of a geometrical white form on a black background and with the brightness relations reversed, with replacing of geometrical bodies by the corresponding contour outlines, and even with partial outlines—on the one hand, this situation was long ago studied thoroughly, and it means that at first only the most general features of the stimuli act and only later, gradually, under the influence of the special conditions, a further analysis takes place and the more special components of the stimuli begin to act. In the given case, at first only com-

binations of white and black points without exact mutual relations and special distribution act as stimuli. This can be shown by the fact that with further planned experiments a white figure on a black background can be differentiated with certainty from a black figure on a white background, *i.e.*, the mutual relationship of black and white will appear as a definite stimulus. The same is true also in the replacing of a geometrical figure by a contour outline, etc. All these are but gradual stages of analysis, *i.e.*, only step by step do the more detailed elements of the stimulus become stimuli in themselves.

In the group of reactions, *i.e.*, in the motor mechanism, the author points out that the rat proceeds correctly in the maze notwithstanding that it sometimes runs quickly, or again moves slowly, or even makes circus movements, as in case of injury to the cerebellum. And this appears to him an objection against a definite connexion of the stimulus with a definite response. However, the rat moves constantly forward and makes turns now to the left, now to the right, with invariably the same muscles in the cases just indicated, and everything else is an additional movement, conditioned by other additional stimuli. Furthermore in the case of the exclusion of muscles throughout the formation of habits during paralysis, and their subsequent use in the cure of the paralysis, it is necessary to know where the paralysis lies and why it arose. For we have a huge series of co-ordinating centres, extending from the end of spinal cord up to the hemispheres, and impulses from the hemispheres may go to one and all. Further we know that with every thought of movement we actually produce it implicitly. And so a process of innervation can occur, although it does not take visible form. And again, if the stimulation cannot be made effective through the nearest path, by the principles of summation and irradiation it has to pass to the most available centres. Have we not long known of the case where a decapitated frog, in wiping off acid placed on the thigh of one side with the foot of that side, if it is unable to do so because of the amputation of that foot, after a few unsuccessful attempts with the disabled extremity, makes use of the foot on the other side?

The allusion to the absence of stereotyped movements in some forms of activity, for example in the building of nests by birds, is also based on a misapprehension. Individual adaptation exists throughout the whole extent of the animal world. And this, precisely, is the conditioned reflex, the conditioned reaction, which takes shape according to the principle of simultaneous action. Finally, his allusion to the monotony of grammatical forms agrees entirely with our previously adduced fact of the working out of system in the nervous processes in the hemisphere in action. This is the combination or fusion of structure with function.

Granted that we cannot now picture clearly how this comes about—this is surely only because we do not yet know thoroughly either the structure or the mechanism of the dynamic processes.

I deem it superfluous to dwell further on the author's arguments against the significance of structure in the central nervous system. The features common to all this are the result of his failure to take into consideration at all the complexity of this structure, already known, with its further possibilities; whereas in a prejudiced way he constantly simplifies it to the bare scheme of a physiological textbook, which aims merely to point out an indispensable connexion between stimulation and effect—and nothing more.

What then does our author offer in place of the reflex theory which he rejects? Nothing except more remote and altogether unjustified analogies. In seeking a solution of the problem of the higher brain mechanism, can one point to the tissue of fungi or hydroids, or to embryonal tissue, when in the higher part of the brain of higher animals including man we have the acme of differentiation of living matter? In any case, recognising absolute freedom of hypothesis, we have the right to demand of the author at least a preliminary and elementary program of definite problems for immediate and fruitful experimentation upon this subject—a prográm which can be profitably compared with the reflex theory, a program which would necessarily bring about an energetic advance in the problem of cerebral functions. But the author has practically no such program. A real and useful scientific theory must not only embody all existing material, but must also open up a wide possibility of further study and, one can say, of unlimited experimentation.

And such is at present the position of the reflex theory. Who will deny the extreme complexity—scarcely imaginable by anyone—of the structure of the central nervous system in its highest types, in the form of the brain of man, and the necessity for a more profound study of it by improved methods? On the other hand, on this very account, the human mind remains overwhelmed by the riddle of its own activity. The reflex theory strives to provide unmistakably a possible ground for both one and the other, and thus to interpret the striking rôle, so difficult to conceive, of this most extraordinary mechanism. The possibility of experimentation on the brain, and especially its higher parts, by means of the reflex theory with its requirements of constant determinism and unremitting analysis and synthesis of the underlying phenomena, is actually without limit. This I have felt and have seen throughout the past thirty years without intermission; and the further I have gone, the greater my conviction.

III

Now that I appear in the psychological literature for the first time, it seems to me a fitting opportunity on the one hand to consider a few tendencies of psychology, which in my opinion do not accord with the aims of successful investigation, and, on the other, to emphasise more sharply my viewpoint on this our common field of work.

I am an empirical psychologist and I know psychological literature only through a few leading psychological texts and, compared with the available material, through an altogether inadequate number of psychological articles which I have read. But from the time when I became really conscious of life, I have been and still am a constant observer and analyser of myself and others in the range of life that is accessible to me, counting in also the best literature and genre painting. I reject point-blank and have a strong dislike for any theory which claims a complete inclusion of all that makes up our subjective world, but I am unable to give up analysing it or interpreting it simply, in its individual points. And this interpretation must result in bringing into accord these individual phenomena and the data of our modern positive knowledge in the natural sciences. And for this it is necessary to endeavour constantly to apply these data to every individual phenomenon in the most elaborate way. And I am now convinced of this: that a purely physiological interpretation of much of what was formerly termed psychic activity has reached firm ground, and with the analysis of the behaviour of the higher animals up to and including man, it has the right to make every effort to interpret the phenomena in a purely physiological way, on the basis of established physiological processes. In the meantime it is clear to me that many psychologists jealously, so to speak, guard the behaviour of animals and man from such physiological explanations, constantly ignoring them and not attempting to apply any of them to any extent.

In confirmation of the statements just made, I take two very simple cases: one, mine, and the other, Professor Köhler's. One could present many others, some much more complex.

When we were working out a method of feeding an animal from a distance, at the time of the experiment we tried out many different methods. This among others: In front of the dog there was always an empty pan, to which a metal tube led down from a container above, which held the dried meat powder and usually served to provide food for our animals at the time of the experiment. At the junction of the container and the tube was a valve, which was opened at the proper moment by means of air transmission, so that a portion of the powder dropped down the tube and came out into the pan where it was eaten

by the animal. The valve was not in good working order and if the pipe were shaken some of the powder from the container would drop into the pan. The dog quickly learned to make use of this, of his own accord shaking out the powder. And a shaking of the pipe took place almost continuously, when the dog was eating the portion of food which was given it and in doing so knocked up against the pipe. Of course this is exactly what takes place in training a dog to give one his paw. In our laboratory work, the conditions of life have in general done the teaching, but here, man forms part of the conditions. In the latter case the word "paw," "give," etc., the skin stimulation from the contact in lifting the paw, the kinesthetic stimulation accompanying the lifting of the paw, and finally the visual stimulation from the trainer, were accompanied by food, *i.e.*, were bound to the unconditioned stimulus for food. It is absolutely the same in the instance cited: the noise of the shaking pipe, the skin stimulation from contact with the pipe, kinesthetic stimulation in jostling against the pipe, and finally the sight of the pipe—all these became similarly connected with the act of eating, with excitation of the feeding centre. This of course occurred through the principle of simultaneous association, presenting thereby a conditioned reflex. And here, moreover, two additional distinctly physiological facts appear: In the first place, the definite kinesthetic stimulation in this case is probably linked up by a conditioned setting (in the lower parts of the central nervous system by an unconditioned setting) with the execution of those movements or the activity which produced it—this kinesthetic stimulation. And, second, when two centres in the nervous system are connected or joined, nervous impulses are set in motion and pass from one to the other in both directions. If we accept the absolute law of one-way conduction of nervous impulses in all points of the nervous system, then in the case cited one must assume an additional connexion in the opposite direction between these centres, *i.e.*, one must grant the existence of an additional neurone connecting them. When food is given on raising the paw, a stimulus undoubtedly runs from the kinesthetic centre to the feeding centre. But when the connexion is established, and the dog, under the urge for food, gives his paw himself, obviously stimulation runs in the opposite direction. I can interpret this fact in no other way. Why this is merely simple association, as psychologists usually assume, and by no means not an act of intelligence, of ingenuity—even if of elementary things—remains unclear to me.

The other example I take from W. Köhler's book, *Intelligenzprufungen an Menschenaffen,* also referring to dogs. A dog is placed in a large cage situated in an open space. Two opposite walls of the cage are solid, through which nothing is seen. Of the other two walls one is a screen, through which clear space can be seen; the other (opposite) has

an open door. The dog stands in the cage behind the screen, and *at some distance* in front of the screen a piece of meat is placed. As soon as the dog sees it, he turns around and goes through the door, around the cage and takes the meat. But if the meat lies *close* in front of the screen, then the dog vainly pushes up against the screen, trying to get the meat through the screen and does not use the door. What does this mean? Köhler does not attempt to decide that question. With conditioned reflexes at our disposal we understand the matter easily. Meat lying near at hand strongly stimulates the olfactory centre of the dog and that centre, by the principle of negative induction, strongly inhibits the rest of the analysers, the other parts of the hemispheres, and thus the track to the door and the roundabout way remain under inhibition, *i.e.,* subjectively expressed, the dog has temporarily forgotten them. In the first case, in the absence of a strong olfactory stimulation, this trace remains under little or no inhibition and leads the dog more correctly to its goal. At all events, this explanation underlies the matter and harmonizes with further exact experimental proof. In confirmation, his experiment would reproduce the mechanism of revery, of strong concentrated thinking about something, when we do not see or hear what is going on around us, or, somewhat similarly, it reproduces the mechanism of what is termed blindness under the influence of passion.

I am certain that with persistent experimentation many other and more complicated instances in the behaviour of animals and man would also prove interpretable from the point of view of many established rules of higher nervous activity.

The second point which I shall take up relates to the question of the significance of the aim and purpose of psychological investigation. It seems to me that on this point there invariably arises a confusion of different things. Before us is the sublime fact of the evolution of nature from the primordial state in the form of nebulae in space, all the way up to human beings on our planet, in the form, to put it roughly, of phases: of the solar and planetary systems, of the inanimate and animate part of nature on the earth. In living matter we see especially strikingly the phases of evolution in the form of phylogeny and ontogeny. We still do not know, and probably will not know for a long time to come, either the general law of evolution, or all its successive phases. But seeing its manifestations, we anthropomorphically, subjectively, both in general and in particular, replace the knowledge of the law with the words "aim," "purpose," *i.e.,* we merely repeat the fact, adding nothing to our present knowledge of it. But in seeking out the truth concerning the separate systems of which nature consists, up to and including man, it all boils down to a mere statement of the internal as well as the external conditions of existence for these systems—in other

words, to the study of their mechanism; and thrusting into this experimentation the idea of purpose in general simply results in a medley of different things and becomes a hindrance to lines of investigation that are accessible to us and that are immediately fruitful. The idea of a possible goal in each system can serve only as a help to our study or the use of scientific imagination for the sake of suggesting new questions and a variety of experiments, just as when we seek to gain familiarity with a machine of which we are still ignorant, and which is the work of human hands; but it is not the final aim.

With this is naturally connected the next question—the question of free will.

This question is of course one of the greatest practical importance. But it seems to me there is a possibility of discussing it, both scientifically (on the basis of contemporary exact natural science), and at the same time not inconsistently with the feeling regarding it that is common to all men, and without involving confusion in its essential formulation.

Man is of course a system—roughly speaking, a machine—like every other system in nature subject to the unescapable and uniform laws of all nature; but the human system, in the horizon of our contemporary scientific view, is unique in being most highly self-regulatory. Among the products of man's hands, we are already familiar with machines which regulate themselves in various ways. From this standpoint the method of investigating the system of man is precisely the same as that of any other system; decomposition into parts, study of the significance of each part, study of the connexions of the parts, study of the relations with the environment, and finally the interpretation on this basis of its general workings and administration, if this be within the capacity of man. But our system is self-regulatory in the highest degree—self-maintaining, repairing, readjusting, and even improving. The chief, strongest, and ever-present impression received from the study of the higher nervous activity by our method is the extreme plasticity of this activity, its immense possibilities: nothing remains stationary, unyielding; and everything could always be attained, all could be changed for the better, were only the appropriate conditions realised.

The system or machine—and man with his host of ideals, aspirations, and achievements—what a terrifying, discordant juxtaposition this seems at first glance. But is it really so? For according to the view of evolution, is not man at the summit of nature, the supreme personification of the resources of a nature which is without limit, the realisation of its powerful but still unknown laws? Is not this sufficient to maintain the dignity of man, to fill him with highest satisfaction? And there still remains in life all that is also embraced in the idea of freedom of will with its personal, social, and civic responsibility; for me there remains

this possibility, and hence also the obligation for me to know myself and, constantly using this information, to maintain myself at the utmost height of my capabilities. Are not the social and civic duties and requirements, situations which present themselves to my system, and which must lead to appropriate reactions that will promote the integrity and perfection of the system? *

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* I am greatly indebted to Dr. R. S. Lyman, who kindly assumed the difficult task of this translation; he has executed it with special care, both in regard to the subject matter of the article and to the particular style of the Russian text.

CHAPTER LIV

LES SENTIMENTS D'EMPRISE [1] AND THE ULTRAPARADOXICAL PHASE

(Open letter to Professor Pierre Janet, *Journal de Psychologie,* XXX, nos. 9-10, 1933.)

DISCUSSION OF JANET'S EXPLANATION OF PERSECUTION—PAVLOV'S EXPLANATION.

Do you not think it a good time to publish this letter in your journal, at the same time giving your opinion on the subject of the ideas which have been suggested to me by the attentive study of your article of last year entitled "Feelings in the Delusions of Persecution"?

I am a physiologist and these last years I have worked, with my collaborators, exclusively on the study of the physiological and pathological function of the superior parts of the central nervous system in higher animals (the dog, in our work), a function corresponding to our higher nervous activity which one ordinarily calls psychic activity. You are a neurologist, psychiatrist, psychologist. It seems to me then that we should understand each other and join our efforts, as we study the function of the same organ.

The third part of your article represents an attempt to interpret the feelings of persecution. The essential abnormality consists in that the invalids see as strangers their own weaknesses and insufficiencies and transfer them to other people. They wish to be independent and they have the invincible feeling that others have made them slaves, executors of their orders; they wish to be well thought of and it seems to them that they are neglected; they wish to have secrets and it seems to them that these secrets are constantly discovered; like everyone they wish to have original ideas: theirs are stolen by others; they have several embarrassing habits from the attacks of the malady, and it seems to them that those habits and those attacks belong to others.

You interpret this state of things in the following manner: These patients have, even in the ordinary occurrences of life, the impression of difficult, unbearable, extremely sad situations. Thus in the example that you give, of the patient who cannot stand the presence at dinner of two ladies that she had known well and against whom she had never

[1] "The word *emprise* is used by Janet in the sense of involvement or grip of a passive as well as active domination of susceptibility ... for this phenomenon of automaticity of relative spontaneity and Pavlov offers an analogy from his experiments in terms of his physiologising of the usually psychologising description."—*Adolf Meyer.*

until now expressed hostile feelings. This constant difficulty and, evidently also, repeated failures fills these patients with anxiety, with great fear and with a desire to escape all these situations. Like children and savages they blame all this on the misdeeds of others: that is what you call intentional objectivity. On this point you again draw attention to the following facts. She is agitated, in the case cited, according to your phrase by double social acts: to be master or slave, to give or to steal, to aspire to solitude or to look for society, etc. In their state of depression the patients are confused by these opposite ideas, and the painful conflict is carried outside, transferred to others. For example the patient greatly desires to remain alone in her locked room where she is alone in reality but she is tormented by the thought that a bad man has gotten in this room and is watching her.

One cannot but approve of all that has been explained, and which represents an extremely interesting psychological analysis. But I ask your permission not to follow you in the interpretation of this last point: you repeat several times that opposite ideas cannot be differentiated between so easily as commonly believed. You write, "The speaker and the spoken of form a whole and cannot be separated as easily as one believes," and further on: "The act of injuring and the act of being injured are joined in the behaviour of the whole injury." You explain this confusion by a combination of very complicated feelings.

Utilizing the facts established and systematised by you, I will take the other course; I will attempt a physiological explanation.

Our general idea of the opposite is a fundamental and indispensable idea which, combined with other general ideas, facilitates, disposes and, even, alone makes possible our normal thought. My relations with the surrounding world, including the social milieu, as well as my attitude face to face with myself, necessarily undergoes serious injury if I constantly confuse contrary ideas or situations; myself and not myself, mine and yours, I am at the same time alone and in society, I offend and I am offended, etc. Consequently it is necessary to have a reason, if there is abolition or weakening of this general idea; and this reason, one can and one must look for, to my mind, in the fundamental laws of nervous activity. I think that the physiology of our day possesses certain signs in this direction.

In studying the higher nervous activity by means of the conditioned reflex we have been able to prove in experiments with our animals the following exact facts: In different states of depression, inhibition (most often in different states of hypnotism), phases of equalisation appear, paradoxical and ultraparadoxical. This shows that the cortical cells instead of effects corresponding to the strength of the excitatory agents, as is the case in the normal state (within certain limits), show in different

cases of inhibition either equal effects, or in inverse proportion to the force of the stimulus, or even opposite to its nature; in this last case, this means that the inhibitory agents have a positive effect, and the excitatory agents a negative effect.

I think—this is perhaps an audacious hypothesis—that it is precisely the ultraparadoxical phase which is the base of the weakening of the idea of the opposite of our patients.

All the necessary conditions for the beginning of the ultraparadoxical state of the cortical cells exist in our patients; you have plainly proven it. These patients in many of the situations of daily life fall easily into a state of depression, of uneasiness, and of terror, as is natural for weak individuals, depending on whether they desire or do not desire certain things and they have the appearance, reinforced by the affectiveness and concentrated in proportion to their strength, of their desires or aversions (I am master, not slave; I wish to be alone and not in society; I wish to have secrets, etc.). That is enough for the representation of the opposite to arise unluckily in these conditions (I am a slave; there is always someone near me; all my secrets are divulged, etc.).

Here is the physiological interpretation of these phenomena. Let us admit that a certain frequency of the metronome acts like a positive conditional alimentary stimulus, its applications having been accompanied by food and provoking an alimentary reaction; that another frequency acts like a negative stimulus, its application not having been accompanied by food and causing a negative reaction (the animal turns aside when one applies it). These two frequencies present a pair of opposites, but the opposites are united by association and at the same time subdued by reciprocal induction, *i.e.,* one frequency stimulates and reinforces the other. Here is an exact physiological fact. Let us go further— If the positive frequency activates a weak cell or occurs in a hypnotic state, it causes (following the law of delimitation, which is also an exact physiological fact) the state of inhibition; in its turn, this state of inhibition, according to the law of reciprocal induction, causes in the other half a state of excitation instead of a state of inhibition, for this reason the stimulant with which it is associated does not now cause inhibition, but on the contrary excitation. This is the mechanism of negativism or of contradiction. You offer food to a dog in the state of hypnotic inhibition, *i.e.,* you invite him to a positive action, to eat, he turns away and does not take the food. You remove the food, *i.e.,* you stimulate him to a negative action, to the inhibition of activity, to the cessation of eating—he turns toward the food.

Obviously this law of reciprocal induction of contrary actions must apply as well to opposite representations, connected naturally with definite cells (verbal) which form at the same time an associated pair. In our

experiments, any difficulty in the higher nervous activity manifests itself by inhibition; on this general background of inhibition, of depression, a slight excitation of a state causes its inhibition, thus inducing the opposite state.

It is easy to imagine that the given interpretation applies as naturally to ambivalence, that symptom so peculiar to schizophrenics appearing very intensively and extensively in the ultraparadoxical states.

Many people, among them those who have a scientific form of thought, become indignant at these attempts at physiological explanations of psychic phenomena, calling them mechanical interpretations in a derogatory sense; I wish here to emphasise the incoherence, the absurdity of a reconciliation between the subjective and the mechanical state. For me there is here a gross misunderstanding.

Certainly, one cannot think, at the present time, of representing our psychic phenomena in a mechanical way, in the strict meaning of the word, just as one would not be able to do so for physiological or chemical phenomena (those latter however are tolerated longer); it has not happened even wholly for natural phenomena.

The true mechanical explanation always remains the ideal of natural sciences; the knowledge of reality, including that of ourselves, one can only approach slowly, and over a long period. The whole of the exact sciences of today make only a long chain of progressive approximations of mechanical interpretation, approximations all the steps of which are united by the supreme principle of determinism: no effect without cause.

One ends with an equal approximation, also far in the future, when one is able to bring back so-called psychic phenomena to physiological actions. It seems to me that one can actually do so in a great number of cases.

From your point of view, the point of view of a psychologist, interpreting the feelings of persecution, you establish the conditions of their appearance, you restore them to the elementary phenomena of which they are composed, and in this way you make clear their general structure, that is, their mechanics, but a very peculiar mechanism.

From my point of view, the point of view of a physiologist, I try to push our common problem a little further in the direction of a true general mechanics, interpreting the confusion of our opposite ideas emphasised by you, as a special purpose of the reciprocal action of the elementary physiological phenomena of nervous excitation and inhibition. In their turn, chemistry first, and then physics will be nearest these last phenomena and their mechanism, approaching the final solution.

tinued until food was given, and then only would the animal turn to the food-box.

Towards the end of the interval between the conditioned stimuli, *i.e.*, before the beginning of the next stimulus, dogs often get into a state of "food excitation" (time reflex), either turning towards the food-box, or to the place of one or the other conditioned stimulus. The above-described animal turns only towards the place from which, long before, the noise had been heard.

Evidently this reaction ought to be considered a pathological one, since it is senseless and crude, distinctly contradicting the existing relationships. Such being our opinion, we decided to put the animal under treatment. A positive result would, of course, have been a further proof of the indisputable pathological character of the reaction. To this end we selected bromides in adequate doses, since we already had had a great many cases in which they were of decisive help in our experimental neuroses and even in cases of constitutional defects of the nervous system.

Under this treatment the reaction weakened considerably. On the application of other stimuli it disappeared altogether, being superseded by an adequate and legitimate motor reaction directed towards the place where these diverse stimuli were situated. Later on the same phenomenon was observed in some other dogs; in one of them similar abnormal reactions were completely obliterated by bromides.

It is clear that in the above-described facts we have a pathological disturbance of the activity of the nerve cells, an alteration of the normal balance between two aspects of their activity (the excitatory and the inhibitory processes) with an abnormal predominance of the excitatory process. This found confirmation in the positive results obtained with bromides—agents which are known to increase the inhibitory function of the cells.

As the extreme weakness of the external agent provoked an unusual tension not only of the general motor orientating apparatus, but also of the special adjusting apparatus of the receptor of the stimulus in question, the overstraining of the excitatory process must be considered as the immediate cause of the pathological phenomenon in the experiment described.

Soon we were able to add to this another similar fact. In dogs of a weak type (but of a stronger variation), and in several castrated dogs of different types, we undertook an investigation on the solving of a difficult problem. The problem consisted in the transformation of the conditioned action of a pair of metronomes with different frequencies and opposite conditioned significations—the stimulus provoking the excitatory process in the cerebral cortex was transformed into a negative one, and the stimulus provoking the inhibitory process into a positive

one (experiments of M. K. Petrova). For this purpose the metronome with the well-elaborated positive effect was applied without reinforcement, and the inhibitory stimulus, on the contrary, was invariably accompanied by feeding. In one of the castrates of an exceptionally strong type, the procedure met with complete success. In the other animals which were submitted to the same test, transformation apparently was taking place, when a peculiar state of affairs set in. In some animals it seemed even as if the object had been attained; several times in succession the metronome gave results corresponding to the new conditions of the experiment. However, later, either gradually or at once, the original relations returned in spite of the fact that the procedure of transformation had been repeated some scores of times and was still being continued.

What was the meaning of this? Was it possible that at this stage of experimentation, in spite of the external similarity in the action of the metronomes to their former action, everything relating to the nature of the excitatory and inhibitory processes in the cell had remained without alteration?

A special investigation was necessary. The experiments that were undertaken revealed serious disturbances of the normal relationships in the nerve cell. The excitatory process now is different from what it was. It has become more stable and less yielding to the inhibitory process. Or it might be understood as a weakening of the inhibitory process, thus leading to the predominance of the excitatory one. The experiments were as follows: when the metronome evoking this changed excitatory process was applied repeatedly in the course of the same experiment without reinforcement by food, that is, was extinguished, it decreased considerably less and much more slowly than the other positive stimuli under similar conditions. And still another peculiarity. Very often after the extinction of the transformed stimulus we failed to observe diminution in the usual effect of the succeeding conditioned stimuli (secondary extinction). This suggested insufficient participation of the inhibitory process in the procedure of extinction of our stimulus. On the other hand, immediately after the extinction of other conditioned stimuli (until a zero reaction) the aforesaid stimulus hardly underwent any change except, perhaps, a very slight weakening. At the same time, other positive stimuli decreased considerably, and even on the following day showed lowered effects. We had here a case of an obvious stability of the excitatory process of the cell, along with a weakening of the inhibitory one. We became aware then of a great difference among other auditory conditioned stimuli in the stability of their excitatory processes. Stimuli differing most from the metronome in the character of their sounds, namely,

tones, remained normal. Stimuli resembling a beating sound approached, in respect of stability, the pathological action of the metronome.

Thus in these experiments on the transformation of the action of metronomes, we obtained the same abnormality as in the case first described: there in the cells of the motor analyser, here in those of the acoustic; in the first case as a result of an overstrain of excitation, in the latter as a result of a clash between excitation and inhibition. In both cases normal relationships were restored after the administration of bromides. This gave one more reason for regarding the weakening of the inhibitory process as one of the mechanisms of the new pathological state, and also enabled us to understand why this fact was observed on castrated animals of the strong type. We have long known that one of the main results of castration consists in the lowering of the inhibitory function of the cell.

Many descriptive names may be applied to the above-mentioned pathological phenomenon—blockage, unusual inertia, increased concentration, exceptional tonicity. Henceforeward we shall preferably use the term "pathological inertness."

These new data confirm and extend our former more general formulations that by functional means (without mechanical interference) one can experimentally obtain in the cortex a very limited pathological point. In our former experiments such a point was represented by paradoxical and ultra-paradoxical phases, *i.e.,* certain stimuli gave greater effects though diminished in strength (contrary to the normal), or even produced a negative instead of a positive effect. The given point either remained in this condition without affecting other points of the hemispheres or passed on into the next pathological stage, when stimulation by its corresponding agent led to a disturbance of the activity of the whole cortex shown by a general inhibition of this activity. Also in our last case we have isolated pathological points, but their pathological state represents a peculiar phase, expressed in the abnormal inertness of their excitatory process.

The foregoing is sufficient evidence for assuming that under the influence of various morbific factors of a functional character distinctly isolated pathologic points or areas may originate in the cerebral cortex. This experimental fact will doubtless fall into place in the pathology of the higher nervous activity in man.

I feel justified in thinking that in the symptoms of *stereotypy,* iteration, perseveration, as well as in obsessive neuroses and paranoia, the fundamental patho-physiological phenomenon is one and the same, namely, that which we observed in our experiments and designated as "pathological inertness." Stereotypy, iteration, perseveration are pathological inertness in the motor area of the cortex (of the general skeletal

as well as the special verbal movements); in obsessive neuroses and in paranoia we have similar inertness in other cortical cells relative to our other sensations, feelings and conceptions. The latter statements, of course, do not exclude the possibility of the appearance of the same pathological state in the lower parts of the central nervous system.

Now let us turn our attention to the clinical setting, in the various neuroses and psychoses, of this pathological phenomenon as an expression of one of the phases of the pathological condition of nerve cells. For instance, stereotypy and perseveration are not uncommon symptoms in hysteria. An hysterical woman complained that when she began to comb her hair she was unable to stop—to end this occupation. Another patient, after a short catatonic attack, could not pronounce a word without numerous reiterations, nor pass over to the next words of the sentence. Still more often these phenomena occur in schizophrenia, where they form the characteristic feature of the disease especially in its catatonic form. Pathological inertness in the motor area either affects separate points or spreads over the whole skeletal-muscular system, as is to be seen in some catatonics in whom any group of muscles once made to move passively continues to do so an enormous number of times.

Further, we shall concentrate our attention specially on the obsessional neuroses and paranoia as separate, independent diseases, where the phenomenon we are interested in constitutes either the essential symptom or the whole of the disturbance.

If pathological inertness can be demonstrated in motor phenomena, it is indeed hardly possible to object to the possibility of the same facts being lawful and admissible in relation to all sensations, feelings and conceptions. Now these phenomena, taken within the limits of the normal, are undoubtedly manifestations of the activity of the nerve-cells. Consequently obsessional neurosis and paranoia would be pathological states of the corresponding cells of the cerebral cortex—in this case a state of pathological inertness. In these forms of morbid disturbances we have stable conceptions, feelings, and, later on, actions which correspond neither to man's relations to nature at large nor to his normal, strictly specialized social relations. Therefore they bring him into difficult, trying, detrimental conflicts with nature, with other people, and, most important of all, with himself. All this, however, applies only to the morbid conceptions and sensations; otherwise these patients think and act as perfectly healthy people, and may even possess capacities above the average.

Obsessional neurosis and paranoia are clinically differentiated as two morbid forms. Not all neurologists and psychiatrists, however, recognize this distinction in the same measure. Some admit transitions from one form to the other, ascribing differences between them to different inten-

sities and phases of the pathological state, and other additional factors.

Here are some quotations from the latter authors. Pierre Janet says: "Persecutory delusions and obsessions are very close to each other, and I wonder why they ever came to be so completely separated." E. Kretschmer: "In connection with the old disputed problem of the existence of any essential difference between delusional and obsessive ideas, we can come to a precise conclusion in the negative sense." R. Mallet: "In this way the delusion would come into line with the obsession . . . the organic injury would be of the same kind."

These two disease forms differ in two fundamental characteristics. In the case of obsessive neurosis the patient is conscious of the morbid nature of his pathological state and struggles against it as far as he is able, though on the whole in vain. In paranoia the patient does not possess this criticism of his state; he is in the power of the disease, in the possession of the persisting sensation, feeling, and conception. The second difference consists in the chronic course and incurability of paranoia.

But these distinctions of the two forms do not essentially exclude the identity of the chief symptom. The more so as many clinicians have doubtless observed cases of acute as well as of chronic transition of obsessions, with retention of critical faculty, into obsessions without this critical faculty. The difference between these forms which has served as a foundation for their clinical separation may have depended on the background from which their general essential symptom has originated, and on the means by which this symptom has been provoked in each case.

First of all let us direct our attention to the predisposing factor and causes of the disturbance investigated in our laboratory material. We have long known in our animals that different experimental neuroses can be produced by one and the same morbid agent, depending on the inborn type of nervous system. Only representatives of the weak type and those of the strong, but unbalanced, type become easily diseased. Of course, it is also possible by intensifying morbid agents to overpower and break even a strong, well-balanced type, particularly if previously the subject was made to undergo some organic disturbance—for instance, castration.

More especially in the case of the transformation of opposite conditioned reflexes (a method of producing the above-described pathological inertness) we had a great variety of results within the normal limits, as well as among pathological deviations, depending on the individuality of the animals. In strong and perfectly normal types this transformation runs regularly towards that required, though differing greatly in speed and in details. In a giant of nervous strength (even after castration), the like of which I have not met during thirty years' work with conditioned reflexes, this transformation started from the very first, and

without fluctuations was completed in the fifth experiment. In other dogs the procedure failed to attain complete success in spite of numerous repetitions; either the new positive stimulus did not reach the effect of the previous one, or the new inhibitory stimulus, contrary to the former, did not attain zero secretion. In some animals it was the positive stimulus which underwent transformation earlier, in others, the negative. All this takes place in cases of successful transformation.

Likewise a great variety of results in relation to the solving of this problem are observed in cases of pathological deviations. As has already been mentioned at the beginning of this paper, either one or another of these deviations takes place. And pathological inertness, as one of the results of transformation, also either speedily changes into some other form of the disturbance or remains more or less stationary. In the weak type, pathological inertness usually soon gives place to some other pathological state. Chronic pathological inertness is particularly often observed in castrated animals of the strong type.

I am now intentionally dwelling on our laboratory material in order to show how various must be the methods of solving the same life problem by people of different types of nervous system, and how diverse must be the pathological results in abnormal types with an incapacity to overcome this difficulty.

So much on the importance of the fundamental factor. As to the proximate causes of the disturbance investigated, we saw in our present experiments (not yet very numerous) two factors provoking its appearance. At one time it is a strong and continuous excitation, *i.e.*, an overstraining of the excitatory process, at another time a collision of the opposite processes.

When we turn to human beings, we must naturally bear in mind here also the different causes as well as different predisposing factors which will determine various degrees and various courses, even of one and the same fundamental morbid disturbance.

Already the first cause which has been studied in our animals opens a wide range of possible causes for the disturbance investigated in humans. Irregular development, occasional accentuation of one or another of our emotions (instincts), disease of some internal organ or of a whole system, may cause the corresponding cortical cells to be temporarily or permanently, excessively, ultramaximally, excited. This finally brings about their pathological inertness—an irresistible concept and sensation which continues to exist long after its real cause has been withdrawn. The same might result from strong and overwhelming life experiences. No fewer, but perhaps more, cases of pathological inertness should be due to our second cause, since the whole of our life is an incessant strug-

gle, a conflict of our innermost aspirations, wishes and tastes with general natural and special social conditions.

The above-mentioned causes would localise the pathological inertness of the excitatory process in different levels of the cerebral cortex. It may take place either in cells receiving immediate stimulation from external as well as internal agents (first signalising system of reality), or in different cells (kinæsthetic, auditory, visual) of the verbal system (second signalising system). In both cases pathological inertness may reach different degrees of intensity, at one time remaining on the level of concept, at another increasing in strength up to real sensations (*hallucinations*).

In our dogs we saw that sometimes, owing to pathological inertness, the effect of the corresponding stimulus distinctly rose above the normal effects of other stimuli.

As to the predisposing factor, it will be a common one in *obsessional neurosis* and in *paranoia, i.e.*, a nervous system inclined to disease, as in our laboratory data. It may be, however, the weak type of the nervous system as well as the strong but unbalanced one. Our laboratory experience has taught us already how essential this difference may be in relation to the character of the disease. It is hardly possible to raise objections in this respect against the lawfulness of the transfer of conclusions from animal to man. Naturally, besides an inherent predisposition one meets with cases of unstable or fragile nervous systems incapacitated by unfortunate occurrences, such as trauma, infections, intoxications and violent emotions.

Consequently, the difference between our two forms of disease in relation to chronicity and incurability is reduced to a difference in the immediate causes of the disease and in the types of nervous systems. The immediate causes of the disease may be either temporary or permanent. In its turn the excitatory process may either be relatively weak, unstable in its nature, easily giving place to the inhibitory one (in the weak type), or strong from the start, altogether dominating the inhibitory process. It is clear that in the latter case pathological inertness has little or no chance of being completely removed or reduced to a degree relatively normal for the given animal. This may be confirmed by the following fact from our laboratory data: in one dog of a more or less strong type, with an obsessive movement, bromides distinctly diminished the obsession, while in another dog of an indisputably weak type the same treatment removed the obsession completely. Besides, it has already been mentioned that a more chronic pathological inertness occurs mostly in castrates of a strong type. In this connexion it is interesting to note E. Bleuler's remark in the latest edition of his textbook—that in cases which he had studied thoroughly he would not like to regard the coincidence of paranoia and sexual insufficiency as accidental.

As to the other feature of distinction between the two forms (the absence of criticism in relation to the morbid symptoms in paranoia and its presence in obsessional neurosis), it must naturally be reduced to the difference in the intensity of pathological inertness. It follows from what has been said before that pathological inertness of the excitatory process in a strong type must be considerable. And this will account for its greater independence and even its inaccessibility to the influence of other undamaged areas of the cortex, and thus will physiologically determine the absence of criticism. Besides, it is probable that the inert excitatory process of considerable force on its periphery will, in accordance with the law of negative induction, initiate strong and irradiated inhibition. This, again, must lead to the same result, *i.e.,* the exclusion of the influence of the rest of the cortex on the above-mentioned process.

Let us illustrate general considerations by concrete examples. Imagine an individual of an excitatory type, that is, one whose excitatory process predominates over the inhibitory. Let us suppose that in his emotional fund (instincts) prevails a rather common tendency to superiority. From his childhood he ardently desires to distinguish himself, to be in the first row, to be leader, to create admiration. But nature at the same time either did not endow him with eminent talents, or unfortunately for him they were not discovered at the proper time, or his conditions in life did not permit of their being applied to practice. In consequence the individual concentrated his energy on an activity foreign to his nature. Inexorable reality denied him everything he aspired to: there was no influence, no laurels; on the contrary, there were blows and rebuffs. Nothing remained but to submit and to reconcile himself to the part of a humble drudge—that is, to inhibit his aspirations. But the necessary inhibition is lacking, and the emotion continuously and imperiously insists upon its own.

Hence at first excessive and vain efforts in one's unfortunate choice of a profession, or a change to some other with similar results. Later on, in accordance with the type (strong), a retirement into self-indulgence by means of constant and vivid representation of one's real or imaginary endowments, rights and privileges, with associated and supporting notions of intentional hindrances and persecutions on the part of the surrounding people. Thus sets in, naturally, a sufficiently conditioned phase of pathological inertness in corresponding points of the cortex, and obliterates there the last remains of inhibition. And now the absolute strength of the idea comes out. Not by means of active inhibition based on other associations, signals, witnesses of reality, but with the help of passive inhibition or negative induction it switches off everything inconsistent with it, and changes into a fantastic conception of imaginary greatness and successes. The emotion lasts to the end of the subject's

life, while alongside of it the morbid ideal lives on, but remains isolated, disturbing nothing that does not come in contact with it. We have genuine paranoia in Kraepelin's sense.

Now I shall analyse two cases from Kretschmer's book, *Der sensitive Beziehungswohn.* They deal with two girls of a more or less weak type, but businesslike and modest, claiming only to an honesty in religious, moral and social relations, without pretensions to rights and privileges in life. Pretensions of the last kind very often, nearly always, combine with a strong excitatory type.

Having attained maturity, the girl experiences a natural sexual attraction towards a man. Individual, ethical and social requirements have not allowed, have detained and are detaining the realisation of this attachment. A clashing between the nervous processes takes place. A disturbed state of the nervous activity ensues, finding expression in pathological inertness in those parts of the cortex which are connected with struggling feelings and conceptions. The girl has the insurmountable, obsessive conception that her sexual attachment is reflected in her face in the form of crude sensuality. In the ward she hides her face in the pillow even before the doctor. Before that stage she avoided going out into the street, as it seemed to her that people looked at her, spoke of the expression of her face and laughed. Although these ideas are imaginary, so far everything remains within the limits of the really possible. Further comes a jump, incomprehensible even as the work of pathologically connected thinking. Under the influence of a conversation with a friend, who affirmed that Eve in Paradise talked with the serpent, not as an intellectual, but as a sexual seducer, the patient attains at once the unexpected and irresistible idea and sensation that a serpent dwells in her inside. It moves continually, and sometimes its head seems to mount as far as the pharynx. We have here a new inert idea. But how, by what process, has it originated? Kretschmer calls the phenomenon "inversion," and believes it to be a reversion to reflex nature (*reflektorischer Umschlag*).

In connexion with an identical phenomenon in another clinical case Kretschmer says: "It has arisen in the manner of a reflex without logical mediation, even in direct opposition to it." What sort of reflex is it, then? Where does it originate and how does it stop? We have met and known this process in the laboratory and can understand its physiological mechanism. At this stage I find it essential to mention, to emphasise, that in this case the physiological and the psychological overlap most evidently; in fact they closely coincide, and, one may say, become identical.

Let us remember the pair of oppositely-acting metronomes, one excitatory, the other inhibitory. If in the cortex there arises a general inhibition, in the form of hypnosis for instance, or locally within the area of

metronome action, the positive metronome becomes negative and the negative positive. This is what we call an ultraparadoxical phase.

In the above-described unexpected conclusion of our patient we come across this truly physiological fact. The girl possessed a constant and deeply-rooted idea of her sexual purity and inviolability. She held it a moral and social stain to experience sexual attachment, even if subdued and not in the least realised. This concept—owing to the generalised inhibitory circumstances in which the patient resides and which, in the weak nervous types, usually accompanies a state of difficulty—irresistibly, physiologically, changes into a reversed one (slightly veiled). The latter, reaching the intensity of a sensation, causes the patient to feel the presence of the sexual seducer in her very body. Exactly the same takes place in the persecutory delusion. The patient wants to be esteemed, and is smarting under the contrary and imaginary ideas of continuous insults; he wants to possess secrets, and is haunted by an obsessive idea, an opposite conception, that all his secrets are perceived by others. Such a physiological interpretation I have already given in an open letter on the subject of obsessive feelings (*les sentiments d'emprise*) addressed to Prof. Pierre Janet.[1]

Consequently, in the present case, at the basis of the delusional state are to be found two physiological phenomena—pathological inertness and the ultraparadoxical phase, existing either separately or conjointly, or in succession.

Approximately the same in the other girl described by Kretschmer; the identical conflict of a natural sexual attachment with a worldly-wise and pertinacious idea of an incongruous difference in years, the object of love being much, much younger; the same consequences, including the inversion, when the patient became tormented by the absurd idea of being pregnant, in spite of the fact that the object of love had never even noticed her inclination to him because of the reticence in the expression of her feelings.

This last case, studied by Kretschmer in the course of many years, shows clearly how obsessive ideas and sensations sometimes reach the intensity of real ideas and sensations and cease to be accepted by the patient as morbid, how they remain at this stage for some time, and then again are recognised by the patient objectively as symptoms of disease. The changes in this case took place in connexion with repeated complications in the surrounding circumstances and consequent changes in the states of the nervous system, either recovering or again oppressed and weakened. Finally, with advancing years everything naturally settled to the normal.

While perusing some books on neurology and psychiatry I was glad to

[1] See chapter LIV of this book.

come across a mention of a theory formulated by the French psychiatrist de Clerambault. According to this theory the primary phenomenon in paranoia consists in the appearance of "intellectual automatism," "parasitic words and ideas," as de Clerambault calls them, round which later the delusion develops. What can be understood under the term of "intellectual automatism" if not a point of a definite pathologically inert excitatory process about which concentrates (according to the law of generalisation) everything intimately connected with it, related, similar to it, and from which is repulsed, inhibited (according to the law of negative induction), everything that is foreign to it.

I am no clinician (I have been and remain a physiologist), and, of course, at present (so late in life) would have neither the time nor the possibility to become one. Owing to this, in my present conclusions as well as in my former excursions into neuropathology and psychiatry, while discussing corresponding material, I dare not aspire to sufficient competency from a clinical point of view. But I certainly shall not be erring now if I say that clinicians, neurologists and psychiatrists, in their respective domains, will inevitably have to reckon with the following fundamental patho-physiological fact: the complete isolation of functionally pathological (at the aetiological moment) points of the cortex, the pathological inertness of the excitatory process, and the ultraparadoxical phase.

CHAPTER LVI

TYPES OF THE HIGHER NERVOUS ACTIVITY, THEIR INTERDEPENDENCE WITH NEUROSES AND PSYCHOSES AND THE PHYSIOLOGICAL MECHANISM OF NEUROTIC AND PSYCHOTIC SYMPTOMS

(Read at the Second International Neurological Congress, London, August, 1935.)

PATHOLOGICAL DISTURBANCES IN THE HUMAN RELATED TO SPEECH—ANALOGIES WITH ANIMAL DISTURBANCES—NARCOLEPSY, ETC. PRODUCED BY WEAKNESS OF EXCITATION—NEURASTHENIA IS WEAKNESS OF INHIBITION—PERSECUTION AND INHIBITION.

We have at our disposal an enormous amount of material obtained by the use of the conditioned reflex method in dogs. Out of this material I shall choose three points concerning the pathological disturbances of the higher nervous activity. These are: 1) the intensity of the fundamental processes of the nervous system, excitation and inhibition; 2) the intensity in relations of these two processes, their equilibrium; 3) finally the movements, the labileness of these processes. These points constitute the basis, on the one hand, for the types of the higher nervous activity, which types play a major rôle in the origin of the so-called psychical diseases; and, on the other hand, for the characteristic alterations in the pathological conditions of the higher nervous activity. . . .

In order to understand the pathological behaviour of man it is necessary to add to the types or temperaments described earlier by us for dogs, the special human types.

Until the time when *homo sapiens* appeared animals were connected with the environment so that the direct impressions fell upon the different receptors and were conducted to the corresponding cells of the central nervous system. These impressions were the several signals of the external object. However there arises in the developing human an extraordinary perfection, the signals of the second order, the signals of the primary signals in the form of *words*—the spoken, the heard, the seen word. Finally it came about that through these new signals everything was designated that the human being perceived both from the environment and from his inner world, and these signals commenced to serve him not only in communicating with other men, but also when he was alone. The chief significance attached to the word was the predominance of these new signals—yet it remained a word, only a second signal of reality. And we know that there are numbers of people who operate only with words from which they deduce everything, would experience every-

thing without coming into contact with reality. And from this they wish to base their own life as well as to direct the lives of others.

Thanks to this second signal of signals and to its constant effects in various aspects of life, all of the human race can be separated into several types: artists, thinkers, and a middle type. The latter unite in proper proportions and activity both signals. These two divisions can be seen among individuals as well as among nations.

I now pass over to the pathology.

We have become convinced in our experimental animals that the chronic pathological deviations from the normal are expressed in the excitable and in the weak type by a mild form of neurosis. The excitable animals lose almost completely the ability for inhibition; in the weak animals, the higher nervous activity is either destroyed completely or becomes chaotic. Kretschmer, who describes only two types corresponding to our excitable and our weak types, as far as I can judge, properly places the manic-depressive psychoses in the first type and schizophrenia in the second. My own clinical experience has been very limited, although I have visited regularly the neurological and psychiatric clinics for the last three or four years, and hence I offer the following remarks presumptively. Constitutional neurasthenia is a form of general weakness, occurring in the middle human type. Hysteria is the result of general weakness in the artistic type; psychasthenia (Pierre Janet), a product of weakness in the thinking type. Hysteria has to do with a general weakness especially of the second signalling signal, which in the artistic type, is normally subservient to the first signal, while in the average person the second signalling system is the highest regulator of human behaviour. Hence the chaotic condition of the activity of the first signalling system and of the emotional background occurs in the form of fantasies with unrestrained motivation and a profound disturbance of the general nervous equilibrium (now paralyses, now contractions, now convulsions, now lethargy) and the consequent chaos in the synthesis of the personality. In the psychasthenic the general weakness is also in the relationship of the organism to the environment, but in the first signalling signal, on the basis of the emotions; therefore, the lack of reality feelings, the complete incapability and uselessness, the ideas of compulsion, phobias, and the constant, distorted melancholy. Thus I conceive in general of the origin of the neuroses and psychoses and their relationship to the human types of nervous activity.

The experimental investigation of the pathological changes in the fundamental processes of the nervous activity makes possible a physiological insight into many neurotic and psychotic symptoms, including individual symptoms as well as those occurring in the symptom complex.

The weakness of the process of excitation leads to a predominance of

inhibition, both in its general form and in its different partial forms, such as sleep and the many phases of hypnosis. The paradoxical and ultraparadoxical phases in the latter state are especially characteristic. To this mechanism one must, I think, refer many pathological symptoms, *e.g.,* narcolepsy, cataplexy, catalepsy, the *"sentiments d'emprise"* of Pierre Janet, or inversion according to Kretschmer, catatonia, etc. The weakness of the excitatory process is produced either by its strain or by its collision with the inhibitory process.

Among the phenomena not yet altogether explainable is the alteration in the movement of the excitatory process, its pathological labileness, as seen in the laboratory. In the clinic this has been known for a long time under the name of "irritable weakness" (*Reizschwache*). It consists in an unusual reactivity, in a weakness of the excitatory process followed by rapid exhaustion. Our positive conditioned stimulus in such cases gives a quick and very unusual effect which, however, during the normal time of action of the stimulus disappears; the positive action drops to zero as it becomes transformed into inhibition. Tentatively we call this phenomenon explosiveness. In our material we also find the opposite pathological alteration in the movement of the excitatory process—pathological inertia. The excitatory process persists even in the face of conditions which should normally convert it into the inhibitory process. The positive stimulation is slightly or not at all influenced by the after-inhibition of the preceding inhibitory stimulus. Such a pathological condition may result from a continually increasing tension of the excitatory process or through its collision with the inhibitory process. The relationship of such symptoms as stereotypy, ideas of compulsion, paranoia, etc., to this pathological persistence of the excitatory process is evident.

The inhibitory process likewise may be weakened either through strain or through collision with the excitatory process. Its weakening results in an abnormal predominance of delay and other normal phenomena of which inhibition is a part, expressed also in the general behaviour of the animal, struggling, impatience, unruliness, and finally as pathological phenomena, *e.g.,* neurasthenic irritability; in man as a hypomanic or manic condition.

My collaborator, M. K. Petrova, who has enriched the experimental pathology and therapy of the higher nervous activity, during the past year has studied these phenomena of pathological labileness of the inhibitory process. A dog who formerly took food from the edge of the table is now no longer able to do this. He shies back and gets as far away as possible from the edge. The significance of this phenomenon is perfectly clear. A normal dog remains standing at the edge by inhibiting his forward movement, to a degree necessary to balance himself. Now

this inhibition is strongly exaggerated. The reaction to depth being excessive, inhibition holds the dog away from the edge more than required for his interest. Subjectively this is doubtless a condition of fear; before us is evidently a state of profound phobia. The phobia could be evoked and also removed, *i.e.*, the experimenter controls the conditions of its origin.* I presume that also the delusion of persecution rests in many cases upon the labileness of the inhibitory process.

Instances of pathological stability of the inhibitory process has been observed previously by us in the laboratory.

Before us remains the difficult task of exact definition in all cases, the statement of when and under what special conditions one or another pathological alteration of the basic process occurs.

* This fact was demonstrated by Dr. Petrova for several days at the XV International Physiological Congress in Leningrad.

CHAPTER LVII

THE CONDITIONED REFLEX

(Written 1935)

HISTORY OF PSYCHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS—CONDITIONED REFLEX CONCEPTS—COMPLEXITY OF THE NERVOUS SYSTEM—SYNTHESIS AND ANALYSIS—CORTICAL INHIBITION—IRRADIATION OF EXCITATION AND OF INHIBITION—PARADOXICAL PHASES—MUTUAL INDUCTION—TRANSMARGINAL INHIBITION—TYPES OF ANIMALS—PHENOTYPE—EXPLANATION OF HUMAN BEHAVIOUR AND EMOTIONS ON BASIS OF CONDITIONED REFLEXES—SYSTEM OF WORD SIGNALS—NERVOUS BREAKDOWN DEPENDENT UPON TYPE OF NERVOUS SYSTEM—ILLUSTRATIONS FROM LABORATORY—BROMIDES—ANALOGIES TO NEURASTHENIA—OBSESSIONS AND INVERSION—CLINICAL CASES—CATATONIA—THERAPY—DISTURBANCE OF EQUILIBRIUM BETWEEN INHIBITION AND EXCITATION—STEREOTYPY AND PERSEVERATION—CYCLISM IN DOGS.

THE conditioned reflex—has now become an independent physiological term for or signifying a definite nervous phenomenon. A detailed study of the latter has resulted in the development of a new branch of animal physiology, *i.e.*, the physiology of the higher nervous activity as a first chapter in the physiology of the higher parts of the central nervous system.

Both empiric and scientific findings have long since shown that a mechanical injury or an affection of the cerebrum, the cerebral hemispheres in particular, caused disturbances in that higher and most complex behaviour of animals and man, generally known as "psychic activity." At present it is barely possible to suppose that any person who has had a medical education may still doubt the premise that our neuroses and psychoses are caused by the weakening or the disappearance of the normal physiological properties of the cerebrum or its greater or lesser destruction. This gives rise to the inevitable and fundamental question: What then is the connexion between the cerebrum and the higher nervous activity of animals and ourselves, how should this activity be studied and what should be the starting point of the investigations?

It seems reasonable that as psychic activity is the result of the physiological activity of a definite mass of the cerebrum, its study should proceed along physiological lines (on the same principles that the activity of all the other parts of an animal organism are now being successfully studied). However, this did not happen for a long time.

Psychic activity has been the object of study of a special branch of science, *i.e.*, psychology, for more than thousands of years, while physiology, applying its usual method of artificial stimulation, succeeded in obtaining the first accurate data concerning a certain physiological func-

tion of the cerebral hemispheres, namely their motor function, at a strikingly recent date, beginning with the seventies of the preceding century; another no less usual method of partial destruction supplied additional data with respect to the connexion existing between other parts of the hemispheres and the main receptors of the organism, such as the eye, the ear, etc. This roused hopes both in physiologists and psychologists of a close bond to be established between physiology and psychology. On the one hand, it became usual for psychologists to begin their manuals on psychology with a preliminary exposition of the teachings on the central nervous system, and on the cerebral hemispheres (the organs of senses) in particular. On the other hand, physiologists in experimenting with the isolation of various parts of the hemispheres, discussed the results obtained on animals from the point of view of psychology, in analogy to that which would have occurred in our inner world (for instance, Munk's observation: "sees but does not understand"). However, this was soon followed by disappointment from both sides. Cerebral physiology seemed to stop with these first experiments and made little further progress; while psychologists, as before, had among their number those of decided views who believed that psychological investigations should be entirely independent of those made in physiology.

Along with this, other attempts were made to connect the triumphant natural sciences with psychology, by applying the method of numerical measurements to psychic phenomena. At one time there was a plan to establish in physiology a special branch of psychophysics, stimulated by the lucky discovery of Weber and Fechner (known as their law) that there existed a definite numerical correlation between the intensity of an external stimulus and the strength of the sensation. However, this one law being established, the branch made no further progress.

Wundt, who was first a physiologist and later became a psychologist and philosopher, was more successful in applying numerical measurements to psychic phenomena in the form of so-called experimental psychology. In this way considerable material has been and is being collected. This mathematical treatment of numerical data is still, after Fechner's example, called by some people psychophysics. But at present it is not unusual to find among psychologists, and among psychiatrists in particular, many who are bitterly disappointed in the active help of experimental psychology.

What, then, was to be done? There was yet another way which might prove effective in solving the fundamental problem, a way whose possibilities were felt, imagined and outlined. Was it not possible to find such an elementary psychic phenomenon that might as well be wholly and rightly considered a purely physiological phenomenon, and having

started with it—by studying with strict objectivity (as is always the case in physiology) the conditions under which it originates, becomes variously complicated and disappears—to obtain first of all an objective physiological picture of the entire higher activity of animals, *i.e.*, of the normal work done by the higher parts of the cerebrum, instead of the earlier experiments of artificial stimulation and destruction?

Fortunately, such a phenomenon had long since been observed by many, had attracted the attention of a number of workers and some had even taken up its study (among those, Thorndike should be mentioned in the first place), but for some reason they had stopped their investigations at the very outset without having elaborated them into the essential and basic method of a systematic physiological study of the higher nervous activity of the animal organism.

The phenomenon consisted in that which is now known as "conditioned reflex," the thorough study of which has fully justified the hopes previously expressed.

Let us make two simple experiments which will always succeed. Some mild solution of any acid is poured into the mouth of a dog. It will cause the usual defence reaction of the animal: by active movements of the mouth the dog ejects the solution and at the same time saliva begins flowing copiously into the mouth cavity (and later escaping), thus diluting the acid which has been introduced and washing it away. Now the other experiment. Let us repeatedly apply to the dog any external agent, for instance, a definite sound, just before introducing into its mouth the same solution. What happens? It will then suffice merely to repeat the sound and the same reaction will be produced, the same movements of the mouth, the same flow of saliva. Both the facts are equally accurate and constant; and to both the same physiological term "reflex" should be applied. Both will disappear if the motor nerves of the muscles of the mouth and the secretory nerves of the salivary glands (*i.e.*, the efferent conductors) are cut, if the afferent conductors from the mucous membrane of the mouth and from the ear are severed, or lastly, if the central stations for conducting the nerve current, *i.e.*, the moving process of nervous excitation from afferent to efferent conductors are destroyed. In the case of the first reflex this will be the medulla oblongata, in the second—the cerebral hemispheres.

In view of these facts the most severely critical mind will fail to offer an argument against this physiological conclusion. But at the same time the difference between the two reflexes is likewise apparent. In the first place, they have different central stations, as has just been mentioned. Secondly, as may be clearly seen from the above experiments, the first reflex was produced without any preparation, without any condition, while the second was obtained by virtue of a special pro-

cedure. What was the meaning of it? In the first case the nerve current was transmitted from one group of conductors to another directly, without any peculiar procedure. In the second—some preliminary was necessary to effect the transmission. It is most natural to suppose that matters stand as follows: in the case of the first reflex a direct road for the transmission of the nerve current was existing, while in the second it was necessary to form previously a way along which the nerve current might pass. The idea had long before originated in nervous physiology and found expression in the German word "*Bahnung.*" In this way the nervous system is found to possess two different central apparatuses: one of direct conduction of nerve current, and, secondly, an apparatus for its switching on and off.

It would have been strange to stand amazed when faced by the conclusion. Indeed, on our planet, the nervous system is an inexpressibly complex and delicate instrument for relations and connexions between the numerous parts of a living organism and between the organism, as a most complex system, and the infinite number of outward factors which may influence it. If, at present, the switching on and off of an electric current has become a most common technical device in our daily usage, surely there is no reason to argue against the realisation of the same principle in the most wonderful instrument that we are now discussing.

On the ground of the above facts we may rightly name a permanent connexion between an external agent and the activity of the organism called forth in response to it "an unconditioned reflex," while a temporary connexion may be defined as "a conditioned reflex."

The animal organism as a system exists in surrounding nature only by means of a constant balancing of this system and its environment, *i.e.*, by means of definite reactions of the living system to the excitations reaching it from outside, which in the case of the higher animals is effected mainly by means of the nervous system in the form of reflexes. The primary means of securing this equilibrium, and consequently the integrity of both an individual organism and its species, are the most simple unconditioned reflexes (such as an attack of coughing if a foreign body has penetrated into the trachea), as well as the most complex unconditioned reflexes generally known as instincts—the alimentary instinct, the defence instinct, the sexual instinct, etc. These reflexes are evoked both by internal agents, originating in the organism itself, and by external agents, owing to which fact the perfection of the equilibrium may be secured. However, the equilibrium achieved by means of these reflexes would have been perfect only providing the environment had been absolutely permanent. But as the environment, in addition to being extremely varied, is constantly fluctuating, the unconditioned connexions, being of a permanent nature, prove to be insufficient and have

to be supplemented by conditioned reflexes, *i.e.,* temporary connexions. For instance, it is not enough that an animal should only take into its mouth food lying in front of it, for then it would often starve and die of lack of food; it is necessary that an animal be able to find food after various casual and temporary indications, which are the conditioned stimuli (signals) causing the animal's movements in the direction of food and finally taking it into its mouth, *i.e.,* resulting in a conditioned food reflex. The same may be said of anything that might be necessary to secure the well-being of an organism or a species both in a positive and a negative sense, *i.e.,* to anything that has to be removed from the environment or to be guarded against.

It needs no great imagination to see at once what countless numbers of conditioned reflexes are constantly used by the most complex system of man, a system placed in an often widely varied general natural environment and, besides, in a special social environment, which in its extreme limit may mean the whole of mankind. Let us consider the same food reflex. What a number of different conditioned temporary connexions, both natural and especially social, are necessary to ensure a sufficient supply of food—and all these are essentially conditioned reflexes.[1] Surely this does not require further explanation!

Let us now pass over to the so-called vital tact as a special social phenomenon. By this we mean the ability of gaining a favourable position in society. What else is this but the characteristic of treating every one and all under any circumstances in a way which would make the attitude of others to us always favourable; this means that we have to change our attitude to other people in accordance with their temperaments, moods and circumstances, *i.e.,* to react to others on the ground of the positive or negative result of previous contacts with them. Of course, there is such a thing as dignified and undignified tact—tact which does not hurt a person's sense of dignity and that of others, and

[1] In this sentence we see the influence of G. H. Lewes' physiology which Pavlov read in his youth and to which he attributes his first interest in physiology. Lewes describes the migrations of peoples as a response to the urge to obtain adequate food supplies. "Hunger is indeed the very fire of life, underlying all impulses to labour....Look where we may we see it as a motive power which sets the vast array of human machinery in action....Hunger is the invisible overseer of the men who are erecting palaces, prison houses, barracks, and villas. Hunger sits at the loom....Hunger labours at the furnace and the plough coercing the native indolence of man into strenuous and incessant activity. Let food be abundant and easy of access, and civilisation becomes impossible: so indissolubly dependent are our higher efforts on our lower impulses. Nothing but the necessities of food will force man to that labour which he hates,...and although this seems obvious only when applied to the labouring classes it is equally true when applied to all other classes, for the money we all labour to gain is nothing but food, and the surplus of food, which will buy other men's labour" (G. H. Lewes, *Physiology of Common Life,* 1860).—*Translator.*

tact of the opposite kind—but in their physiological essence both are temporary connexions, or conditioned reflexes.

Hence, the temporary nervous connexion is a universal physiological phenomenon both in the animal world and in our own. And at the same time it is likewise a psychic phenomenon, which psychologists call an association, no matter whether it is a combination of various actions or impressions, or that of letters, words, and thoughts. What reason might there be for drawing any distinction between what is known to a physiologist as a temporary connexion and to a psychologist as an association? Here we have a perfect coalescence, a complete absorption of one by the other, a complete identification. Psychologists seem to have likewise acknowledged this, for they (or at any rate some of them) have made statements that experiments with conditioned reflexes have provided associative psychology, *i.e.,* such psychology as believes the association to be the foundation of psychic activity, with a firm basis. This is the more so because by means of an established conditioned stimulus it is possible to form a new conditioned stimulus; and of late it has been convincingly proven on an animal (a dog) that even two indifferent stimulations, repeated one after the other, become interconnected, one causing the appearance of the others.

In physiology the conditioned reflex has become a central phenomenon the use of which makes it possible to study with ever greater completeness and exactness both the normal and the pathological activity of the cerebral hemispheres. In the present paper this study which has by now supplied us with an enormous number of facts can, of course, only be described in its main features.

The essential condition necessary to the formation of a conditioned reflex is in general the coinciding in time (one or several times) of an indifferent stimulation with an unconditioned one. This formation is achieved most rapidly and with the least difficulty when the former stimulations directly precede the latter, as has been shown in the instance of the auditory-acid reflex.

A conditioned reflex is formed on the basis of all unconditioned reflexes and out of all the possible agents of the inner and outer world both in their elementary form and in their largest complexes subject to only one limitation: the cerebral hemispheres must be provided with the corresponding receptory elements. We have before us the broadest synthesis realised by this part of the cerebrum. But this is not all. The conditioned temporary connexion is at the same time specialised to a degree of the greatest complexity and to that of the greatest disintegration of both the conditioned stimuli and certain activities of the organism as well, the skeleto-motor and the verbal-motor activities in particular. Here is the most subtle analysis, as a product of the same

cerebral hemispheres. Hence the vastness and depth of adaptation or equilibrium of an organism with its environment.

Synthesis is, evidently, the phenomenon of switching on of the nerve current. What then is analysis if considered as a nervous phenomenon? There are several separate physiological phenomena. The initial basis for analysis is provided by the peripheral endings of all the afferent nerve conductors of the organism, each of them being specially adapted for transforming a definite kind of energy—both from outside and inside the organism—into the process of nervous irritation, which is then conveyed both to the special, less numerous cells of the lower divisions of the central nervous system and to the excessively numerous special cells of the cerebral hemispheres. However, having reached these latter, the nervous process as a rule diffuses, irradiating over various cells to a greater or lesser distance.

That is why when we have once elaborated, let us say, a conditioned reflex to one definite tone, not only other tones but many other sounds may produce the same conditioned reaction. In the physiology of the higher nervous activity this is known as the generalisation of conditioned reflexes. Consequently, in this case the two phenomena, that of switching on the current and that of irradiation, occur simultaneously. But irradiation is gradually further and further limited; the excitatory process is concentrated in the minutest nerve-point of the hemispheres, apparently, in a group of the corresponding special cells. The limitation is effected most rapidly by means of another essential nervous process—inhibition. It develops as follows: We first have a generalised conditioned reflex to a definite tone. We then continue experimenting with it, constantly accompanying it by its unconditioned reflex, thus reinforcing it. Next we shall apply other tones, but without reinforcing them. In this way the latter will gradually lose their effect, and this will at last happen to the tone which lies nearest to the one used for the conditioned reflex; for instance, the tone of 500 vibrations will produce the desired effect, while that of 490 will fail to do so, or in other words, a differentiation between the two will have been achieved. The tones which now fail to produce the previous effect are inhibited. This may be proved as follows: if, having applied the inhibited tone, we immediately test the constantly reinforced conditioned tone, it will either produce no effect whatsoever, or its effect will be considerably weaker than usual. It means that the inhibition which has abolished the effects of alien tones has likewise made itself felt on that of the conditioned tone. This, however, is but a transient effect, no longer observed when a greater interval is allowed after the abolished tones have been applied. Hence, it follows that the inhibitory process irradiates in the same way as that of excitation. But the more frequently the non-reinforced tones

are repeated the more restricted is the inhibitory irradiation, the inhibitory process becoming more and more concentrated both in time and in space. Consequently, analysis begins with the special work of the peripheral apparatus of the afferent conductors and is completed in the cerebral hemispheres by means of the inhibitory process. The above described case of inhibition is known as differential inhibition. We shall now consider other cases of inhibition. Generally, in order to obtain a conditioned reflex of a definite more or less constant magnitude the action of the conditioned stimulus is made to last for a definite time after which an unconditioned stimulus is added, reinforcing the first. In this case the first few seconds or minutes of stimulation, depending on the duration of the isolated action of the conditioned stimulus, are of no effect, for being premature signals of an unconditioned stimulus they are inhibited. This is the analysis of the different moments of the continuous action of a stimulus. The given inhibition is known as the inhibition of a delayed reflex. But the conditioned stimulus—as a signal—is corrected by inhibition, gradually approaching zero if it is left to act without reinforcement for a certain period of time. The latter phenomenon is known as *extinction.* It lasts for some time and then disappears spontaneously. The restoration of an extinguished, conditioned effect of a stimulus is accelerated by means of reinforcement.

In the above cited cases we have had to deal with the special inhibition of the cerebral hemispheres, or *cortical inhibition.* It originates under definite conditions in places where it had not previously existed, it fluctuates in intensity, it disappears if conditions are changed. In all this it differs from the more or less constant and stable inhibition of the lower segments of the central nervous system and has, therefore, been called internal to distinguish it from the latter (external). However, it would have been more correct to call it "elaborated conditioned inhibition."

In the work of the cerebral hemispheres inhibition takes as permanent, complicated and subtle a part as the excitatory process. Just as stimulations conveyed to the hemispheres from outside are in some cases connected there with definite points which are in a condition of excitation, so certain stimulations, likewise on the basis of coincidence in time, may in other cases form a temporary connexion with the inhibitory condition of the cortex, if the latter is found to be in a condition of inhibition. This clearly follows from the fact that these stimuli have an inhibitory effect and in themselves give rise to an inhibitory process in the cortex, becoming conditioned negative stimuli. In this case, as in the cases previously cited, the excitatory process is converted under certain conditions into a process of inhibition. This will seem to be more or less comprehensible if we take into consideration the fact that

transformation of various forms of energy into an excitatory process is constantly going on in the peripheral apparatus of the afferent conductors. Why then should not the energy of the excitatory process be transformed into that of the inhibitory process and vice versa?

As we have just had occasion to see, both the excitatory and the inhibitory processes, having originated in the hemispheres, first, diffuse and irradiate over them, after which they may concentrate, converging to the initial point. This is one of the essential laws of the entire central nervous system, but, here, in the cerebral hemispheres it acts with the mobility and complexity peculiar only to the latter. Among the conditions which determine the onset and the course taken by irradiation and concentration of the processes, the force of both the processes should be regarded as being of primary importance. The material so far collected permits of the conclusion that a weak excitatory process tends to irradiate, moderate excitation tends to concentrate, whereas strong excitation again tends to irradiate. Exactly the same may be said of the inhibitory process. Irradiation in cases of very intense processes has been met less often and, therefore, has been less thoroughly studied, particularly in the case of inhibition.

The irradiation of the excitatory process of low tension as a temporary phenomenon reveals the latent condition of excitation caused either by another stimulus (however, too weak to make itself evident) or by a stimulus which had recently been in action, or again from a frequently repeated stimulus which had left an increased tonus of some definite point. On the other hand, this irradiation removes the inhibitory condition of other cortical points. The latter phenomenon is called "disinhibition" and consists in an irradiation wave of a weak alien stimulus transforming the effect of a definite negative conditioned stimulus in action to the reverse, positive effect. An excitatory process of average tension concentrates, converging to a definite limited point and finds expression in effecting some definite work. Irradiation occurring under conditions of very strong excitation causes a maximum tonus of the cortex when against the background of this excitation, all the other successive excitations likewise produce a maximum effect.

Irradiation of the inhibitory process of low tension is the condition known as hypnosis and is revealed in conditioned food reflexes by both its components, the secretory and the motor. When inhibition (either differential or of any other kind) arises under the above conditions, it most commonly causes peculiar conditions in the cerebral hemispheres. To begin with, contrary to the rule of a normally more or less parallel change in the magnitude of the salivary effect of conditioned food reflexes in accordance with the intensity of the stimuli, all the stimuli are equalised in their effect (the phase of equalisation). Further, weak

stimuli produce more saliva than strong ones (paradoxical phase). And, lastly, a perversion of effects occurs: the positive conditioned reflex produces no effect whatever, whereas the negative conditioned reflex causes salivation (ultraparadoxical phase). The same is observed as regards the motor reaction; so, when a dog is offered food (*i.e.*, natural conditioned stimuli are put into action), it turns away from it, while when the food is pushed or carried away the dog tries to reach it. Besides, it is sometimes possible to observe directly in the condition of hypnosis (in the cases of conditioned food reflexes) a gradual spreading of inhibition over the motor region of the cortex. The first to be paralysed are the tongue and the muscles of mastication, after which the inhibition of the cervical muscles sets in, and, finally, that of all the muscles of the trunk. A further spreading of inhibition down the brain presents sometimes a state of catalepsy and finally manifests itself in heavy sleep. The hypnotic condition, being an inhibitory one, readily enters into a temporary conditioned connexion with numerous external agents of simultaneous occurrence. When strengthened, the inhibitory process concentrates. This serves to draw a delimitation between cortical points in a condition of excitation and those of inhibition; and as the cortex contains numbers of most varied points, both of excitation and inhibition, referring both to the outward (visual, auditory, etc.) and the inner (motor, etc.) world, it presents an enormous mosaic with alternating points in a condition of excitation or inhibition varying in quality and the degree of tension.

In this way the waking working condition of both animal and man is a mobile and at the same time localised fractioning—sometimes very minute, sometimes less so—of the excitatory or inhibitory condition of the cortex which is opposed to the state of sleep when inhibition reaches its climax both in intensity and extensiveness, spreading uniformly over the entire mass of the hemispheres and penetrating down to a certain depth. Yet even then there may remain in the cortex separate points of excitation, of watchfulness which are, so to speak, "on duty." Consequently, in the waking state both the processes seem to be in a constant but mobile equilibrium or in constant struggle. If a large number of external or internal stimuli suddenly cease to act on the cortex, inhibition at once markedly outweighs excitation. Some dogs having the peripheral receptors (visual, auditory and olfactory) destroyed are known to sleep twenty-three hours out of the twenty-four.

Another essential law constantly at work, besides that of irradiation and concentration of nervous processes, is the law of mutual induction—the effect of a positive conditioned stimulus grows when the latter is applied immediately following or soon after a concentrated inhibitory stimulus, and, conversely, the effect of an inhibitory stimulus is found

to be more precise and profound following a concentrated positive stimulus. Mutual induction is revealed both around the excited or inhibited point, simultaneously to their action, and in the point itself, after the processes have ceased.

It is obvious that the law of irradiation and concentration and that of mutual induction are closely connected with each other, mutually limiting, counterbalancing and strengthening each other, thus effecting an exact correlation between the activities of the organism and the conditions of its environment. Both the above laws are observed in all the parts of the central nervous system, but in the cerebral hemispheres they are revealed in the newly forming points of excitation or inhibition, whereas in the lower sections of the central nervous system they are observed at more or less constant points.

Negative induction, *i.e.*, the appearance or strengthening of inhibition around the point of excitation was in previous expositions on conditioned reflexes termed "external inhibition," if the given conditioned reflex was found to weaken or disappear, owing to a casual, alien stimulus acting on the animal, most frequently producing a reflex of orientation. This offered the opportunity to unite the above described cases of inhibition (extinction, etc.) under the term of internal inhibition, as one occurring without the interference of any stimulation coming from the outside. In addition to these two different cases of inhibition occurring in the cerebral hemispheres, there is yet a third case. When the conditioned stimuli are physically very strong, the rule of the direct correlation between the magnitude of the effect caused by them and their physiological intensity is destroyed: their effect is no longer stronger but weaker than that produced by stimuli of moderate intensity—such is the case of the so-called transmarginal inhibition. The transmarginal inhibition appears both in the case of a single strong stimulus and in the case of a summated effect of several stimuli, each of which is not very strong in itself. Transmarginal inhibition should most naturally be classified as a case of refractory inhibition. If the cases of inhibition were to be further systematised, they should probably be classified as constant unconditioned inhibition (inhibition of negative induction and transmarginal inhibition). However, there is reason to regard all these types of inhibition as being one and the same process physico-chemically but merely originating under different conditions. The elaboration and spread of excitation and inhibition over the cortex of the hemispheres, providing they have occurred at a definite period owing to the effect of external and internal stimuli, in a uniform and constantly repeated environment, are seen to become more and more fixed and to develop ever more readily and automatically. In this way there appears in the cortex a dynamic stereotypy (a functional system) which requires less

and less nervous work to sustain it. This stereotypy also becomes inert and often difficult to change, so that it can hardly be overcome by a novel environment or new stimuli. Any original elaboration of a stereotypy requires a considerable and sometimes excessive amount of energy, depending on the complexity of the system of stimulations.

The study of conditioned reflexes in numerous dogs has gradually pushed to the front the question as to the various nervous systems of different individuals. At last the data obtained provided sufficient grounds for classifying nervous systems according to certain essential features peculiar to them. These features are three in number: the force of the main nervous processes (of excitation and inhibition), their degree of mutual equilibrium, and the mobility of these processes. In fact, combinations of these three features are represented by four more or less markedly manifest types of nervous systems. According to the force of the nervous processes, animals have been classified as strong or weak; strong animals falling into two groups: those having well-balanced nervous processes and those having unbalanced processes; strong, well-balanced animals again form two groups—labile and inert animals. This approximately corresponds to the classic systemisation of temperaments. There are strong but unbalanced animals, having strong processes of both excitation and inhibition, but with a predominance of the former over the latter. These go to form the excitable, unrestrained type, or, according to Hippocrates, the choleric type. Then we have strong well-balanced animals, which are inert—this is the calm unperturbable type, or phlegmatic type, after Hippocrates. Further, strong, well balanced and labile animals—a very active, mobile type, or sanguine type, after Hippocrates. And, lastly, a weak type of animals which resemble most the melancholic temperament distinguished by Hippocrates; their common prevalent feature is their liability to inhibition, owing to the constantly weak and readily irradiating internal inhibition, and, particularly, to external inhibition produced by the action of different alien stimuli which in themselves may be of no great significance. In other respects this is a less uniform type than all the others. At one moment this is the animal which has equally weak processes of excitation and inhibition, in which an excessively weak inhibitory process is found to prevail at another moment; it may be either restless and constantly looking about or on the contrary, constantly stopping and remaining motionless as if rooted to the spot. The cause of this lack of uniformity lies, of course, in the fact that animals of the weak type, just as those of the strong types, may be distinguished according to other features besides the energy of their nervous processes. However, the prevalent and excessive weakness of either inhibition alone or of both the processes nullifies the vital value of variations according to other features. The

permanent and strong liability to inhibition reduces all these animals to the same degree of invalidism. Thus, type is an innate constitutional kind of the nervous activity of an animal—or a genotype. But, as an animal from the time of its birth is subjected to the various effects produced by its environment which it inevitably has to answer by definite activities that often may become fixed for the rest of its life, the final nervous activity present in an animal is an alloy of the features peculiar to the type and of the changes wrought by the environment—*i.e.*, the phenotype, or character.

All the above stated facts may obviously be regarded as indisputable physiological material, *i.e.*, as an objective reproduction of the normal physiological work of the higher parts (suprasegmental) of the central nervous system. And, indeed, the physiological study of any part of an animal organism should and, as a rule, does begin with the study of the normal work it performs. But this does not prevent certain physiologists from denying up to the present that the facts reported above have any reference to physiology—not an infrequent instance of adherence to convention in science.

There is no difficulty in establishing a natural and direct connexion between the above described physiological work done by the cerebrum and the phenomena of our own subjective world in many of its points. The conditioned connexion is apparently, as we have previously mentioned, what we call in ourselves an association by simultaneity. The generalisation of a conditioned connexion corresponds to what is known as association of similarity. The synthesis and analysis of conditioned reflexes (or associations) are essentially the same fundamental processes as those of our mental work. When absorbed in thought, when carried away by some work, we cease to hear or to see what is happening around us—which is an obvious case of negative induction. Who would be able to draw a line of distinction, in analysing the most complex unconditioned reflexes (or instincts), between physiologico-somatic and psychic phenomena, *i.e.*, isolate the experience of powerful emotions of hunger, sex attraction, anger, etc., from respective physiological phenomena? Our feelings of pleasantness or unpleasantness, of easiness or uneasiness, of joy, torment, triumph, despair, etc., are connected either with the transformation of the most powerful instincts and their stimuli into corresponding effector acts or with their inhibition followed by all the possible variations of either an easy or obstructed course of the nervous processes going on in the cerebral hemispheres, as may be observed in dogs which solve or are unable to solve nervous problems of various degrees of complexity.

Our contrast emotions are, of course, phenomena of reciprocal induction. Under conditions of irradiated excitation we say and do things

that we should never have considered permissible when composed. Apparently, the excitation wave has transformed the inhibition of certain points into a positive process. A marked loss of memory for things of the present—a usual phenomenon in normal old age—is due to the reduced mobility of the excitatory process especially or its inertness owing to age, etc.

The developing animal world on reaching the phase of man acquired an exceptional supplement to the mechanisms of nervous activity. To an animal, reality is signalled almost exclusively merely by the stimulations—and the traces that they leave in the cerebral hemispheres—conveyed directly to the special cells of the visual, auditory, and other receptors of the organism. This is what we likewise possess in the form of impressions, sensations and conceptions of the environment, both of the general natural environment and of our social environment, with the exception of words—visible and audible. This first system of signalling reality is the same in our case as in the case of animals. But words have built up a second system of signalling reality, which is only peculiar to us, being a signal of the primary signals. The numerous stimulations by word have, on the one hand, removed us from reality, a fact we should constantly remember so as not to misinterpret our attitude towards reality. On the other hand, it was nothing other than words which has made us human, but this, of course, cannot be discussed here in greater detail. However, it is beyond doubt that the essential laws governing the work of the first system of signalling necessarily regulate the second system as well, because it is work done by the same nervous tissue.

The most manifest evidence of the fact that the study of conditioned reflexes has directed us along the right course in investigating the higher parts of the cerebrum and that, in this way, the cerebral functions and the phenomena of our own subjective world have been at last joined together and identified has been obtained from further experiments with conditioned reflexes carried out on animals. They have succeeded in reproducing certain pathological conditions affecting the human nervous system—such as neuroses and certain psychotic symptoms—with the result that in many of the cases it was found possible to achieve a rational and intentional return to the normal standards or in other words to effect a cure—a genuine scientific mastering of the subject.

The normal standard of nervous activity is one in which all the above processes participating in this activity are found to be in a condition of equilibrium. The disturbance of equilibrium results in a pathological condition or disease; but not infrequently this so-called normal condition, or, to be more exact, the relatively normal condition is in itself characterised by a certain lack of equilibrium. Hence the probability

of a nervous affection is clearly connected with the type of nervous system. Among dogs, those most rapidly and readily developing nervous affections as a result of hard experimental conditions are animals belonging to the two extreme types: the excitable and the weak types. Of course, by applying extremely strong and excessive measures it is possible to disturb even the equilibrium of animals belonging to the strong and well-balanced type. The hard conditions which chronically disturb nervous equilibrium consist in the overstraining of the excitatory process, in the overstraining of the inhibitory process and in the direct collision of both these opposed processes, or in other words in the overstraining of the mobility of these processes.

Let us consider a dog having an established system of conditioned reflexes to stimuli of varying physical intensity, of reflexes both positive and negative which arise in a stereotyped order and after fixed intervals. By applying first excessively strong conditioned stimuli, then by greatly prolonging the inhibitory stimuli or by applying very subtle differentiation or again by increasing the number of inhibitory stimuli in the system of reflexes and, lastly, by making the two opposite processes follow each other in immediate succession, or even by the simultaneous action of two opposed conditioned stimuli, or by suddenly altering the dynamic stereotypy, *i.e.*, by transforming the established system of conditioned stimuli into the opposite series of stimuli, we have occasion to observe that in all the above cases the previously mentioned extreme types are the first to develop a chronic pathological condition, which is manifested differently in these two types. In the excitable type a neurosis consists in that the animal's inhibitory process, which was constantly weaker as compared with the excitatory process even under normal conditions, now diminishes very markedly or almost disappears: the established, though not absolute, differentiations are completely disinhibited, extinction is greatly lengthened, the delayed reflex is turned into one but shortly delayed, etc. The animal becomes, in general, highly unrestrained and nervous during the experiments in the stand: it either becomes panicky or, much less frequently, falls into a condition of drowsiness which had never been previously observed. A neurosis displayed by the weak type of dog is almost exclusively of a depressive nature. The conditioned reflex activity becomes very disorderly and, most frequently, entirely disappears; while in the stand the animal is almost without exception in a hypnotic condition, revealing the different phases of the latter (no conditioned reflexes can be observed, the animal does not even take food).

Experimental neuroses are usually permanent, affecting an animal for months and even years. Some of the existing therapeutic methods have been successfully applied in the treatment of these chronic neuroses.

Bromides had been administered long before in the study of conditioned reflexes in dealing with animals which were unable to cope with the task of inhibition. It was found that bromides helped them considerably. The long and varied series of experiments with conditioned reflexes in animals have proved beyond doubt that bromides are directly connected with the inhibitory process (which they reinforce by raising its tonus) and not with the excitatory process which they were previously supposed to reduce. Bromides have proved to be a powerful regulator and restorer of disturbed nervous activity but only providing the essential condition of adequate and exact dosage corresponding to the given type and condition of nervous system is observed. The dose to be given to dogs of the strong type which are so far in a fairly strong condition is large—from 2 to 5 grams per day; while in the case of the weak type the dose should be reduced to centigrams or even milligrams. Such use of bromides for a couple of weeks in some cases of chronic experimental neuroses effected a complete and radical cure.

Recently experiments are being made which have shown that still better results may be obtained, in particularly severe cases, by the combined effect of bromides and caffein, but again providing the most exact, in this case relative, dosage is observed. Ill animals were sometimes also cured, though not as rapidly and completely, by merely shorter or prolonged regular rest from the laboratory work in general or by the mere removal of the more difficult tasks in the system of conditioned reflexes.

The above described neuroses in dogs should be most naturally compared with neurasthenia in man, the more so that certain neuropathologists insist on their being two forms of neurasthenia: excitatory and depressive neurasthenia. Besides, certain traumatic neuroses and other reactive pathological conditions may also be regarded as belonging to the same group.

The acknowledgement of two systems of signalling reality in man will, naturally enough, lead to a special understanding of the mechanism of the two types of human neuroses: hysteria and psychasthenia. If human beings can be classified—in accordance with the prevalency of the one system over the other—as essentially thinkers and essentially artists, then in pathological cases under conditions of a generally disturbed nervous equilibrium, it is obvious that the former will be found to develop psychasthenia, the latter—hysteria.

In addition to establishing the mechanism of neurosis the physiological study of the higher nervous activity provides a clue towards understanding certain phenomena of psychoses. In the first place, we shall consider certain forms of delusions, namely, variants of persecutory delusions, called by Pierre Janet *"les sentiments d'emprise"* or those called *"in-*

version" by Kretschmer. The patient is persecuted exactly by the things that he is most eager to escape: he longs to keep his thoughts secret and is forever suffering from the delusion that they are being revealed and discovered by other people; he wishes to be alone, and is tortured by the thought that there is somebody else in the room, even though he be there by himself, etc., *i.e.*, *les sentiments d'emprise* according to Janet. Kretschmer has observed two cases in which a girl having reached puberty and developed sexual feeling for a given man had suppressed this feeling. As a result, both girls developed a fixed idea—to begin with, they were tortured by the thought that every one's attention was drawn by the expression of sexual excitation that could be read on their faces, while they were very particular about retaining their chastity. Then suddenly one of them became possessed by a constant delusion and even sensation that a sexual seducer—the serpent, which had tempted Eve in paradise, lived inside her, moving and reaching as far as her mouth. The other girl suddenly imagined that she was pregnant. This latter phenomenon was called by Kretschmer "inversion." Apparently, in its mechanism it is identical to that of obsessive feelings (*les sentiments d'emprise*).

It would not be a far-fetched conclusion to say that this subjective pathological experience may be interpreted as a physiological phenomenon of the ultra-paradoxical phase. The idea of sexual inviolability, as a particularly strong positive stimulation which stood out against the background of an inhibitory condition of depression that both the girls found themselves in, was transformed into the opposite negative idea, which was quite as strong, reaching the stage of an actual sensation—in the one case the idea of there being a sexual seducer within her body, in the second, of pregnancy which was the result of sexual intercourse. The same may be said of the patient affected with obsessive feelings—a strong positive idea, "I am alone," is turned under the same conditions into a similar but opposite idea, "There is always some one near me."

Experiments with conditioned reflexes in cases of various complicated and pathological conditions of the nervous system have often revealed that temporary inhibition results in a temporary alleviation of these conditions. In one dog a manifest catatonic condition, which was observed twice, led to a marked improvement of a chronic nervous affection which had not yielded to treatment. The improvement consisted in an almost completely restored normal condition which lasted some few days.

In general it should be mentioned that experimental affections of the nervous system are almost invariably characterised by symptoms of hypnosis, which gives reason to suppose that this is a normal physiological means of struggling against a morbific agent. Therefore, catatonia, or the schizophrenic phase, which is wholly made up of hypnotic symp-

toms, may be interpreted as physiological protective inhibition, either restricting or completely excluding the work of the affected brain which was threatened by the danger of serious disturbance or final destruction through the action of some injurious agent, so far unknown. Medicine is well aware of the fact that in the case of the vast majority of diseases the first therapeutic measure is to provide rest for the affected organ. The correctness of a like interpretation of the mechanism of catatonia in cases of schizophrenia is confirmed by the fact that only this form of schizophrenia shows a fairly high percentage of cases who return to their normal condition in spite of a very lasting catatonic condition, in some cases of many years (as much as twenty). From this point of view any attempts to treat people affected with catatonia by any stimulating methods or remedies seem positively injurious. Conversely, one should expect a considerable rise in the percentage of recoveries if the physiological rest secured by means of inhibition were to be combined with intentional external rest provided for such patients. They should by no means be kept under conditions of constant and strong stimulations reaching them from their environment among other more or less restless patients.

The study of conditioned reflexes, besides revealing the general affections of the cortex, has repeatedly revealed extremely interesting cases of experimentally and functionally developed affections of separate very minute points of the cortex. Consider the instance of a dog with a system of varied reflexes and among them conditioned reflexes to various sounds—such as tone, noise, a metronome, the ring of a bell, etc. It has been found possible to make only one point of application of these conditioned stimuli morbid, whereas all the others remain sound. The pathologic condition of one isolated point of the cortex is achieved after the same methods that have been described above as being morbific. The disease may manifest itself in various ways and by various degrees of intensity. The slightest change affecting the given point becomes evident through its chronically hynotic condition: an equalising or paradoxical phase develops at this point instead of the normal relation between the magnitude of the effect caused by stimulation and the physical intensity of the stimulus. On the grounds of the previously stated considerations, this might likewise be interpreted as a physiological protective measure in the case of a difficult condition of a given point. A further development of the morbid condition results in the stimulus failing to produce any positive effect whatever and always causing nothing but inhibition. This is found to occur in one series of cases; in another series the phenomena develop in exactly the reverse order. The positive reflex becomes usually stable: it undergoes extinction at a much slower rate than normal reflexes; it is less subject to after-effect inhibi-

tion caused by other conditioned inhibitory stimuli; it often stands out in its magnitude among all the other conditioned reflexes, which was never observed before the affection developed. Hence it follows that the excitatory process of the given point has become chronically and pathologically inert. The excitation of the pathological point either remains indifferent to all the other points of the cortex or else it becomes impossible to stimulate this point without disturbing in some way the entire system of reflexes. There is reason to believe that in an affection of isolated points characterised by the prevalence of one of two processes, whether the inhibitory or the excitatory, the mechanism of the morbid condition consists precisely in the disturbance of equilibrium between the two opposed processes—mostly either one or the other of the two processes is found to be considerably weakened. In cases of pathological inertness of the excitatory process, bromides—which serve to increase the inhibitory process—have been frequently found to effect a recovery.

The following conclusion will hardly be considered as fanciful. Obviously, if *stereotypy,* iteration and *perseveration* have natural grounds for existing in pathological inertness of an excitatory process of various motor cells, then the mechanism of obsessional neurosis and paranoia must be the same. The only difference lies in that in the latter case other cells or groups of cells which are related to our sensations or conceptions are involved. In this way only one series of sensations and conceptions connected with the affected cells becomes abnormally stable and does not yield to the inhibitory effect of numerous other sensations and conceptions which are in better accord with reality, owing to the normal condition of their cells.

Another fact which was frequently observed in the study of pathologic conditioned reflexes and which is obviously related to human neuroses and psychoses is the cyclism displayed by nervous activity. Disturbed nervous activity appeared to be more or less regularly fluctuating. First came a period of extremely weakened activity (conditioned reflexes were chaotic and often entirely disappeared or were reduced to a minimum); after several weeks or even months this was followed as though spontaneously and without any apparent reason by a more or less complete return to the normal condition—which was sometimes even entirely reestablished—only to be succeeded by another period of pathological activity. In other cases this *cyclism* was manifested by alternating periods of weakened activity and of abnormally increased activity. One cannot fail to see an analogy between these fluctuations and cyclothymia and manic-depressive psychoses. It would be most natural to attribute this pathologic periodicity to the disturbance of a normal correlation between the excitatory and the inhibitory processes

as far as their interaction was concerned. Owing to the fact that these opposed processes failed to restrict each other, the result of their work reached an extreme and only then did one process succeed the other. In this way another periodicity develops, namely, an exaggerated one which lasts a week or a month instead of the short and, therefore, quite easy daily periodicity.

Finally, it is impossible not to mention a fact which has been so far revealed in an exceptionally severe form, it is true, only in one dog; namely, the excessive explosiveness of the excitatory process. Certain conditioned stimuli, or even all of them, produced a rapid and excessive effect (both motor and secretory), which was, however, soon stopped while the stimulus was still in action and the dog refused to take food when the food reflex was reinforced. Apparently, this was due to a great pathologic lability of the excitatory process, a condition corresponding to the excitatory weakness clinically observed in man. Mild forms of the phenomenon are not infrequent among dogs under certain conditions.

All the above pathological nervous symptoms may be revealed under adequate conditions both in normal dogs, *i.e.*, such as have not undergone any operation, and in castrated animals (particularly some of the pathological conditions, as cyclism), *i.e.*, on an organically pathological substratum. Numerous experiments have shown that the main feature of the nervous activity of castrates is mostly a greatly weakened inhibitory process, which, however, becomes more or less restored with time in the case of the strong type.

In conclusion it is necessary to emphasize once more how much the physiological phenomena and those experiences of our subjective world mutually overlap and intermingle, when comparing on the one hand the ultraparadoxical phase with obsessive feelings and inversion, and, on the other hand, the pathological inertness of the excitatory process with obsessional neurosis and paranoia.

APPENDICES

I

A LETTER TO THE YOUTH

A letter addressed to young scientists written by Pavlov in 1936, shortly before his death, and referred to as his "last will and testament."

What would I wish for the youth of my fatherland who devote themselves to science?

First of all—Consistency. I can never speak without emotion of this most important condition for fruitful, scientific work. Consistency, consistency, and still more consistency.[1] From the very beginning of your work train yourselves to be strictly systematic in amassing knowledge.

Learn the ABC's of science before attempting to ascend its heights. Never reach for the next step without having mastered the preceding one.

Never attempt to cover up the gaps in your knowledge by even the most daring conjectures and hypotheses. No matter how the colourings of this bubble may please your eye, it will inevitably burst leaving you with nothing but confusion.

Train yourselves to discretion and patience. Learn to do the manual labour in science. Study, compare, and accumulate facts.

No matter how perfect a bird's wing, it could never raise the bird aloft if it were not supported by air. Facts are the air of the scientist. Without them you will never be able to soar. Without them your "theories" are useless efforts.

Yet, while studying, experimenting, observing, try not to stop only at the surface of facts. Do not become an archivist of facts. Try to penetrate the mystery of their origin. Seek persistently the laws governing them.

Second, modesty. Never think that you already know everything. No matter in what high esteem you are held always have the courage to say to your self: "I am ignorant."

Don't allow yourself to be overcome by pride. On account of pride you will be stubborn where it is necessary to be conciliatory; you will

[1] The literal translation of the Russian word used by Pavlov is "consistency," however, in the introduction it is freely translated as "systematic planning." See the quotation from Professor Babkin in section III of the introduction.

reject useful advice and friendly assistance; you will lose your sense of objectivity.

In the group which I am called upon to direct, atmosphere is everything. We are all harnessed to one common cause and everyone furthers it to the best of his strength and ability. Frequently we can not distinguish what is mine and what is thine, but through this our common cause only gains.

Third, passion. Remember, science requires your whole life. Even if you had two lives to give it would still not be enough. Science demands of man effort and supreme passion.

Be passionate in your work and in your quests.

Our fatherland opens broad vistas to scientists, and we must truthfully say science is being generously introduced into the life of our country. Extremely generously.

What is there to say about the position of a young scientist in our country? It is perfectly clear. To him is given much, but of him much is demanded. And it is a matter of honour for the youth, as well as for all of us, to justify those great hopes which our fatherland places in science.

II

PAVLOV IN THE KREMLIN

During the XV International Physiological Congress held in Leningrad in 1935, the delegates journeyed to Moscow for a one-day session. A reception for the delegates was held by the Soviet Government in the Kremlin on August 20. Addressing the delegates from foreign countries, Pavlov said:

"How exceptionally favourable is the position of science in my fatherland! I want to give only one example to illustrate the relations which arose in our country between the government and science. We, the leaders of scientific institutions, are really alarmed and uneasy over the question whether or not we are in a position to justify all those means which the government places at our disposal. As you know, I am an experimenter from head to foot.

"My whole life has consisted of experiments.

"Our government is also an experimenter, only on an incomparably higher plane. I passionately desire to live in order to see the victorious completion of this historical social experiment."

III

PAVLOV IN RYAZAN

Greetings at a dinner tendered by representatives of social, cultural, professional, and labour organisations at Ryazan, Pavlov's birthplace, August 21, 1935.

"I should like to say that representatives of science were feted formerly, too, but those celebrations were in a narrow circle of people of the same kind, so to speak—men of science. That which I see now, in no way resembles those limited celebrations. In our country the whole population honours science. I saw that this morning in the meeting at the railway station, on the collective farm, and on my way here. I would not be mistaken, I think, in saying that this is to the credit of the government at the helm of my country.

"Formerly science was divorced from life and alienated from the people, but now I see it is otherwise—I see that the whole nation respects and appreciates science. I raise my glass and drink to the only government in the world which could bring this about, which values science so highly and supports it so fervently—to the government of my country."

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